IRON AND STEEL ENGINEER

J. F. KELLY, Editor

CONTENTS

Vol. IV. October, 1927 No. X

Inspection Trip Jones & Laughlin Steel Corp..... II

Editorials III

Operation of Series Motors in Parallel When Rigidly Coupled to the Same Load—By J. A. Jackson..... 423

The Automatic Control of Synchronous Motors..... 427
By J. H. Hall.

Discussion: Electric Development Committee Report 436
By Membership.

Discussion: Fifteen Years of Steel Mill Illumination—What Change—By Membership..... 438

Discussion: Application of Synchronous Motors in Steel Mills..... 443
By Membership.

Electrical Installations at Alliquippa Plant of the Jones & Laughlin Steel Corporation—By R. M. Hussey..... 448

Discussion: Electrical Installations New Structural Mills, Carnegie Steel Company, Munhall, Pa.—By Membership..... 452

Discussion: Recent Boiler Plant Installation at Edgar Thomson Works, Carnegie Steel Company—By Membership..... 453

Items of Interest 455

(List of Advertisers Page IV)

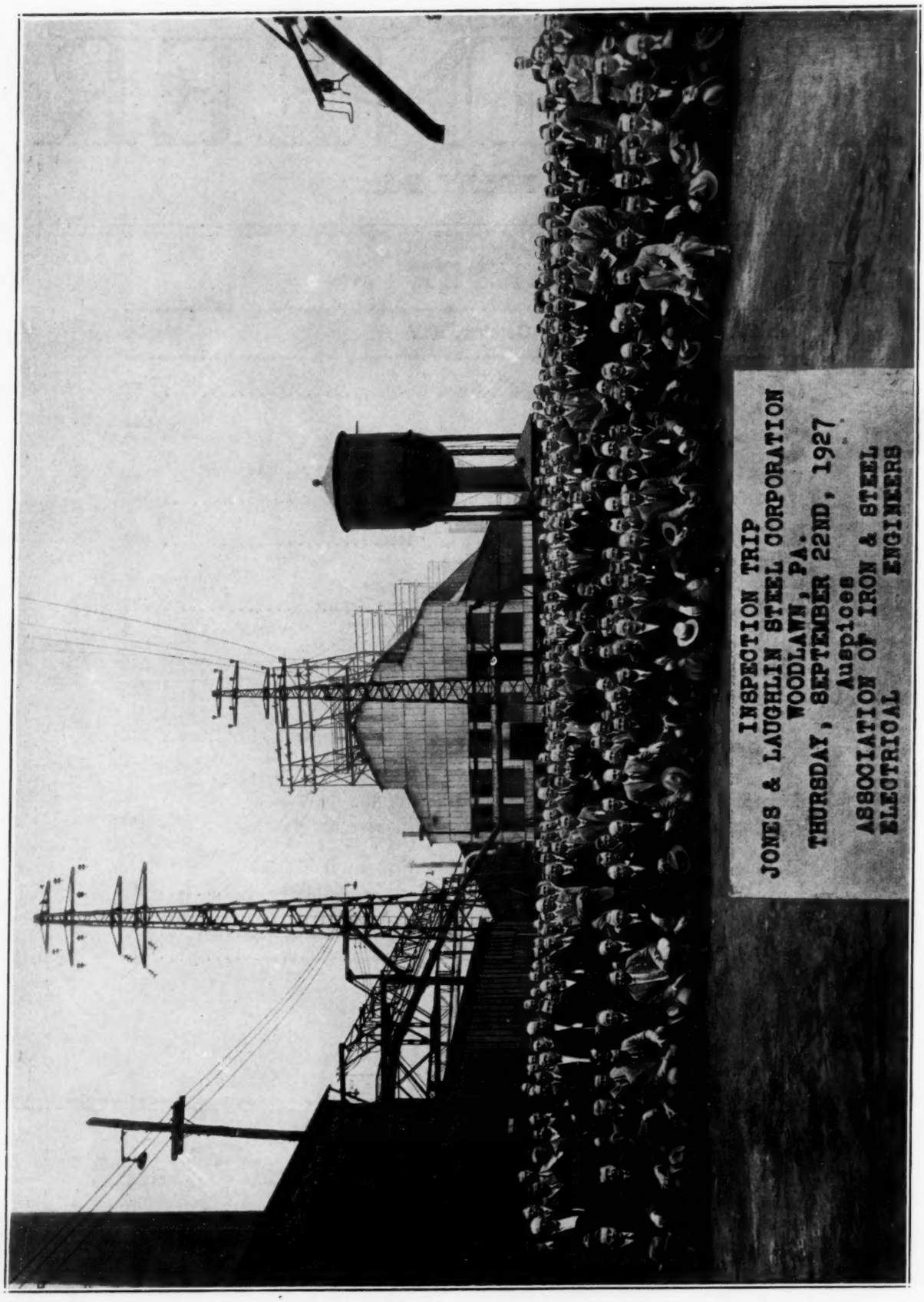
Published Monthly by

Association of Iron and Steel Electrical Engineers

706 Empire Building, Pittsburgh, Pa.

Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.

Subscription Price $5.00 per Year. Single Copy 50c.


INSPECTION TRIP
JONES & LAUGHLIN STEEL CORPORATION
WOODLAWN, PA.
THURSDAY, SEPTEMBER 22ND, 1927
Auspices
ASSOCIATION OF IRON & STEEL
ELECTRICAL
ENGINEERS

EDITORIALS

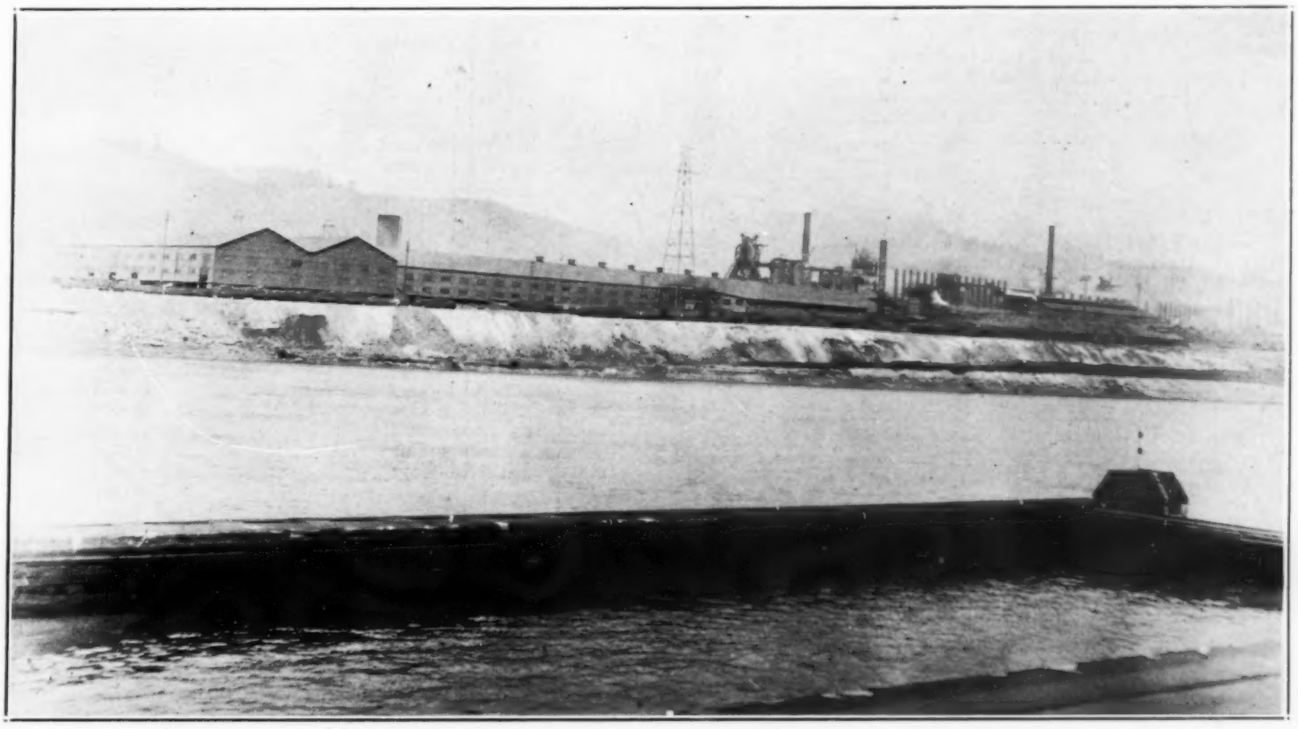
ANNUAL MEETING OF A. I. & S. E. E., ELECTION OF OFFICERS

INSPECTION TRIP—JONES & LAUGHLIN STEEL CORPORATION

On Thursday, September 22, 1927, 350 members of the Association of Iron and Steel Electrical Engineer inspected the plant of the Jones & Laughlin Steel Corporation at Woodlawn, Pa.

The trip through this plant, one of the largest and most modern in America, proved to be one of the most interesting and instructive in our history.

A special train left Pittsburgh at 12:45 p. m. and arrived at Woodlawn at 1:15 p. m.



General View of the Blast Furnaces and Rollings Mills.

The party was divided into groups of 20 and they were escorted through the various departments, beginning first at the South Power House, past the Tin Plate, Rod and Wire Departments, 30″ Round Mill, Seamless Tube Plant, then by train to the By-Product Coke Plant, back to the 14″ Mill, 10″ Skelp Mill, Billet, Bar and Blooming Mills, then through the Open Hearth and Bessemer Departments, then to the Blowing Engine Room, through the North Power House and Switch Tower to the Blast Furnace Department.

The special train left Woodlawn at 6 p. m. and arrived at Pittsburgh at 6:30 p. m. Special street cars carried the party to the William Penn Hotel where dinner was served.

(Continued on page 455)

INSPECTION TRIP PITTSBURGH STEEL COMPANY, ALLENPORT, PA.

As announced in our September issue, Mr. Homer D. Williams, President, Pittsburgh Steel Company, has extended an invitation to our members to inspect the new Pilger Mill of this Company at Allenport, Pa.

It was originally planned to visit this plant on October 28th, but this has been changed until later in November.

While no definite date has been decided upon as yet, tentative plans call for the trip to be made during the week of November 13th.

As you know, this is the first time any group of American engineers have had the opportunity of visiting a mill making tubes by the German Process. An inspection of the plant is particularly interesting in view of the fact that all the motors and control as well as the mill proper are of German manufacture.

No other place in this country affords a better opportunity of comparing foreign and American practices in steel mill electrification. The mill is completely electrified and requires 10,000 HP to drive the 152 motors installed.

Should you desire to make a visit to the plant, you are requested to write to the Association headquarters at 705 Empire Building, Pittsburgh, Pa., and upon receipt of your request, an official pass, together with all necessary details, will be forwarded to you.

INDEX TO ADVERTISERS

A

Alliance Machine Company 491
Allis-Chalmers Mfg. Company 508
American Heat Economy Bureau 480

B

Baker-Raulang Company 497
Bartlett Hayward Company 502
E. W. Bliss Company 477
Boxill-Bruel Carbon Company 512
Bussmann Manufacturing Company 505

C

Clark Controller Company 495
Cleveland Crane & Engineering Co. 501
Condit Electrical Mfg. Corp. 506
Crocker-Wheeler Electric Mfg. Co. 511
Crouse Hinds Company 499
Cutler-Hammer Mfg. Company 464–465
Cutter Electrical Mfg. Company ..... Cover 3

D

De Laval Steam Turbine Company 487–489
Delta Star Electric Company 492
M. H. Detrick Company 516
Doubleday-Hill Electric Company 493

E

Economy Fuse & Mfg. Company 514
Electric Controller & Mfg. Company 479
Electric Power Equipment Corp. 510
Electric Service Supplies Company 468

F

Fafnir Bearing Company 515
Farrel Foundry & Machine Company 496
Fawcus Machine Company 491
Freyn Engineering Company 469

G

General Electric Company 462–463–Cover 4
Graybar Electric Company 484–509

H

Hyatt Roller Bearing Company 504

I

Iron City Electric Company 483

J

W. J. Jeandron 472
Johns-Manville Corp. 503

K

Keystone Lubricating Company 498

M

Martindale Electric Company 489
Moloney Electric Company 490
Monitor Controller Company 513
Morgan Construction Company 484
Morgan Engineering Company 470
Morganite Brush Company 482

N

National Carbon Company 461
Nichols-Lintern Company 458
Norma-Hoffmann Bearings Corp. ..... Cover 1
R. D. Nuttall Company 473

O

Ohio Electric & Controller Co. 475

P

Pittsburgh Transformer Company 488
Pyle-National Company 482

Q

Queen's Run Refractories Company 485

R

Reliance Electric & Engineering Co. 474
Roller-Smith Company 485
Rowan Controller Company 492
Rockbestos Products Corp. 476
Rollway Bearings Company 471
Rumsey Electric Company 490

S

Shepard Electric Crane & Hoist Co. 494
SKF Industries, Inc. 507
Smith & Serrell 486
Stackpole Carbon Company 500
Standard Underground Cable Company 486

T

Timken Roller Bearing Company 466
Thompson Electric Company 487
Tool Steel Gear & Pinion Company 488
Trumbull Electric Mfg. Company 481

U

United States Graphite Company 493

V

V. V. Fittings Company 478

W

Westinghouse Electric & Mfg. Company 459–460–483–Cover 2
Weston Electrical Instrument Company 481
Edwin L. Wiegand Company 467

Operation of Series Motors in Parallel When Rigidly Coupled to the Same Load*

By J. A. JACKSON†

THE operation of two series wound D.C. motors by a single controller when the motors are mechanically coupled together to the same load is perfectly good practice provided the control connections are suitably arranged. If the series field and armature circuits of the two motors are kept entirely separate by using separate reversing contactors or segments in a drum switch, the motors will balance the load very closely provided their speed torque curves are identical, even though there may be an appreciable difference in the resistance of the two branches of the circuit due to longer leads to one motor. Slight irregularities in manufacture may cause their characteristics to differ slightly but the unbalancing of the load between the two motors will usually not be over 5 per cent from this cause while the danger of exchange currents between the two motors is entirely eliminated except when stopping by back torque, commonly known as plugging. Exchange currents while plugging can be prevented by using an independent plugging resistor in each motor circuit although the accelerating resistance, may with perfect safety, be common for the two motors.

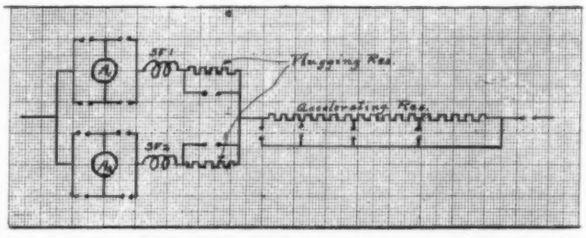


FIG. 1—Control connection which may be used for two series motors, rigidly connected to the same load and subjected to plugging duty.

Dangerously high currents can be obtained when plugging if the plugging resistance is left out of the loop circuit and placed in the line in series with the accelerating resistance. These high currents occur if there is any unbalancing of resistance in the two branches of the loop circuit and are caused by a circulating current in the loop circuit which does not appear in the line. When the plugging resistance is placed inside the loop as shown in Figure 1 its resistance is so high that circulating currents in the loop are eliminated. Figure 1 shows these connections, which may be considered good practice for two motors applied as previously mentioned.

Occasionally economy in selecting control equipment leads to the error of using common reversing contactors or drum switches with single reversing segments for motors mechanically connected to the same load which frequently results in unsatisfactory operation. The purpose of this article is to analyze this connection and show why such a control connection is dangerous.

Figure 2 shows this connection diagrammatically and in the discussion the upper motor will be referred to as motor No. 1 and the lower motor as motor No. 2. The leads to the series field and armature of motor No. 2 are shown longer than those of motor No. 1 such as is likely to be the case where the motors are driving the bridge motion of a crane with motor No. 1 and the controller near one end of the crane and motor No. 2 located near the other end of the crane. Obviously this makes the resistance of the series field and armature circuits of motor No. 2 greater than the resistance of the corresponding circuits of motor No. 1 which difference in resistance may be made still larger by loose or dirty joints in the circuits of motor No. 2. This difference in resistance can be the cause of serious trouble and in order to show what happens in the various circuits, the current torque and speed curves have been calculated for two 85 H.P., 230-volt series motors, 30 minute rated, with the resistance of the two branches slightly unbalanced.

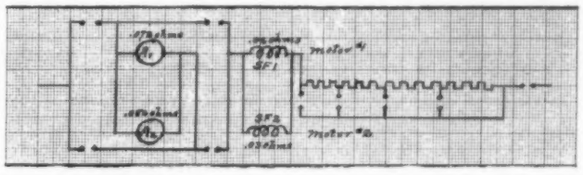


FIG. 2—Control connection which may be used for two series motors rigidly connected to the same load and subjected to plugging duty.

The resistance of the series field of each motor is .018 ohms and the resistance of each armature, including commutating field and brush drop, is .07 ohms. It has been assumed that the resistance of the leads to the series field and the armature of motor No. 1 have a resistance of .002 ohms each making the total resistance of the series field circuit .02 ohms and the armature circuit resistance equal .072 ohms. For motor No. 2 the leads to the field are assumed to have a resistance of .012 making the total resistance of the field circuit .03 ohms and an equal resistance for the armature leads makes the armature circuit resistance .082 ohms. This amount of unbalancing is entirely within reason and may occur in the circuits of two motors so connected.

For any given current in the common line, the division of this current in the two series fields can be easily calculated as it will be in an inverse ratio to the respective resistances of the two circuits. The current in the two armatures is not dependent on ohms law (except at zero speed) but is governed by the C.E.M.F. which in turn is dependent on the speed and the field flux. The speed of the armatures must be identical as they are coupled together and this speed can be calculated for any line current by the formula which is deduced later in the

*Presented before Cleveland Section, February 25, 1927.

†Industrial Engineer, General Electric Co., Schenectady, N. Y.

article. After obtaining this speed, the C.E.M.F. and current in each armature can be calculated and in each case the algebraic sum of the currents in the two armatures must equal the current taken from the line.

Figure 3 shows the speed and the torque current curves for each individual armature, the speed current curve of the line current and the combined torque current curve of the two motors. The minimum current whichever flows in No. 2 armature is 400 amperes and occurs at the point where the current in armature No. 1 is zero or where it changes from a motor current to a generator current. For

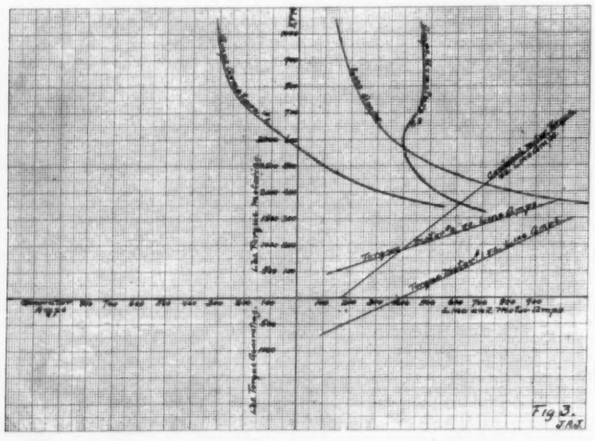


FIG. 3—Curves for connection shown in Fig. 2 showing line current and current in armatures No. 1 and No. 2 plotted against speed and torque of motors No. 1 and No. 2 and the combined net torque of the two motors plotted against line current. Resistance of field and armature circuits unbalanced.

light torque loads, armature No. 1 has a generator current of over 300 amperes flowing in it. As the half hour rated current of **each** motor is 320 amperes it is seen that the armature of motor No. 2 is **always** overloaded and armature No. 1 may have close to rated current in it when the torque load is light such as usually exists on the bridge motion of a crane after acceleration is completed. If the resistance of the two circuits is unbalanced to a greater extent than assumed in this case, the overload current in armature No. 1 and the generator current in armature No. 2 becomes still greater.

The ratio between the torque of the two motors with unbalanced circuits and the torque of the same motors with balanced circuits depends; first, on the ratio of the unbalancing of the circuits and; second, on the amount of torque demanded by the load. The greater the unbalancing, the greater the reduction in torque delivered by the unbalanced motors. For heavy loads the reduction in torque delivered by the unbalanced motors is relatively small but for light loads the reduction becomes a much larger percentage until at some critical speed the net torque delivered by the unbalanced motors is zero.

It will be seen that at 930 RPM the net torque of the motors is zero as at this speed the generator torque required by motor No. 1 is exactly equal to the motor torque delivered by motor No. 2. Thus, 930 is the maximum speed which can be attained by the motors and can be reached only when the motors are running light and not connected to any external load. If driven above this speed by an overhauling load the net torque delivered by the unbalanced motors will result in electric braking.

Curves M_1 and M_2 on Figure 5 show the current in each individual armature when operating with an external resistance of .9 ohms in series with the two motors. Curves N_1 and N_2 on Figure 5 show each armature current when operating with an external resistance of .5 ohms in series with the two motors. These curves are calculated for both positive and negative speeds to determine the currents when plugging the motors. They show that while overloads do occur in armature No. 1 when plugging, there is very little tendency to get generator currents in armature No. 2 and then only when plugging from speeds above 700 RPM. The current curve of armature No. 2 with .5 ohms external resistance begins to assume the same general shape as the current curve for armature No. 2 in Figure 3.

Calculation of Curves

Obviously the basis of calculation for the speed current and torque curves must be the speed current and torque curves of one of the duplicate motors being used. These curves are given in Figure 6. The curves shown in Figure 7 are necessary to determine the field flux constants used in the formula for various values of amperes in the fields. These curves are deduced directly from Figure 6 and the $\frac{T}{A}$ curve shows the relation between torque and current for different values of field amperes. The curve is

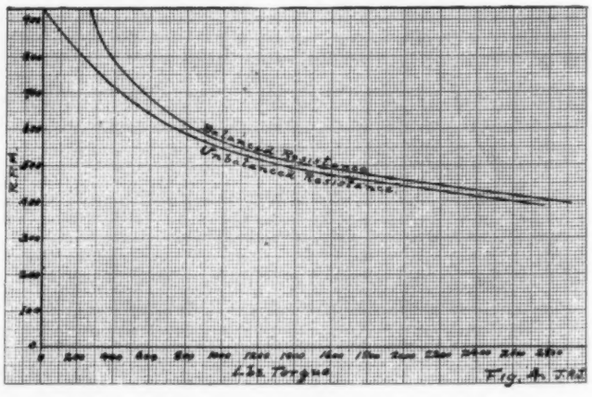


FIG. 4—Curves for connection shown in Fig. 2 showing combined net torque of the two motors plotted against speed for balanced and unbalanced resistance in the armature and field circuits.

obtained by dividing foot pounds torque by the corresponding current value and plotting the result against the current. The quotient of this division is the foot lbs. torque delivered per ampere of current in the armature so long as the field strength is maintained at the value for which the $\frac{T}{A}$ is obtained.

The $\frac{V}{R}$ curve expresses the relation between the C.E.M.F. generated per revolution per minute for different values of field strength and is obtained by; first, reading from Figure 6 the 230 volt speed for various current values; second, the C.E.M.F. is obtained for these same current values by subtracting

from 230 volts the Cr drop in the motor; third, the $\frac{V}{R}$ value (K in the following formula) is obtained by dividing the C.E.M.F. so obtained by the speed at the corresponding current value; fourth, the curve is then drawn by plotting $\frac{V}{R}$ (or K) against the corresponding current value.

The calculation of the speed and torque current curves for two motors connected as in Figure 2 is started by assuming any convenient and reasonable

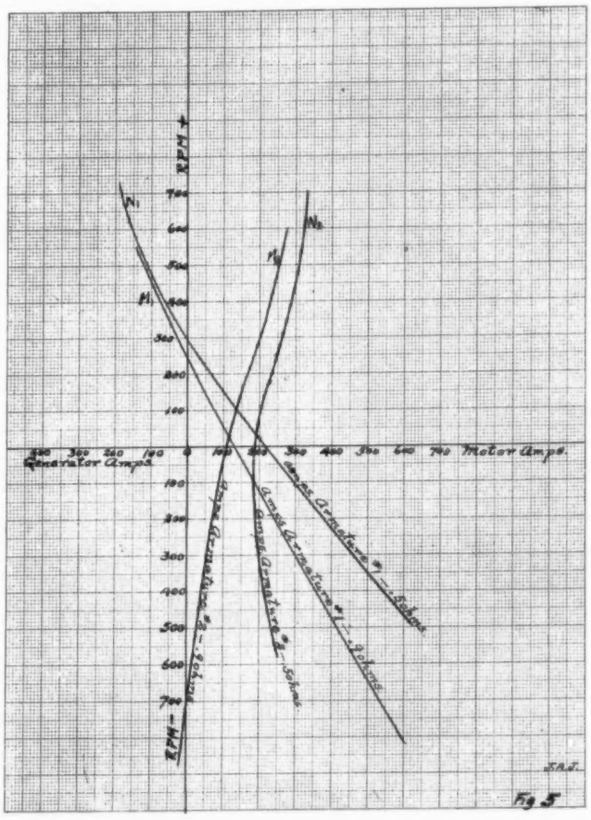


FIG. 5—Curves for connection shown in Fig. 2 to show effect of plugging. M_1 and M_2 speed when operating with an external resistance of .9 ohms. Curves N_1 and N_2 show the currents in each armature when external resistance is .5 ohms.

line current C and determine the division of this current between the two series fields which division will be in inverse ratio of their resistance. For the particular case under consideration three-fifths of the line current will go through the field of motor No. 1 and two-fifths through the field of motor No. 2. The constant K then can be determined for each motor from $\frac{V}{R}$ curve in Figure 7 by reading the two values from the curve corresponding to the two field currents and let K_1 be the value for motor No. 1 and K_2 the value for motor No. 2.

Next determine the Cr drop in the series field circuit and subtract it from 230 volts to get the volts impressed across the two armatures. Call this value E.

The resistance of the leads and armature of motor No. 1 will be represented by r_1 and for motor No. 2 by r_2, while the speed in R.P.M. of the two motors which must be the same will be represented by S.

Then:

$$C = \frac{E - K_1 S}{r_1} + \frac{E - K_2 S}{r_2} \qquad (1)$$

Solving (1) for S we have:

$$S = \frac{E (r_1 + r_2) - C r_1 r_2}{K_1 r_2 + K_2 r_1} \qquad (2)$$

From which the speed of the two motors can be obtained.

Then:

$E - SK_1 = E_1 =$ C.E.M.F. of armature No. 1 (3)

$E - SK_2 = E_2 =$ C.E.M.F. of armature No. 2 (4)

and:

$$\frac{E_1}{r_1} = C_1 = \text{current in armature No. 1} \qquad (5)$$

$$\frac{E_2}{r_2} = C_2 = \text{current in armature No. 2} \qquad (6)$$

Then: $C_1 + C_2 = C$ (7)

For many values of C_1 E_1 is found to be negative (SK_1 is greater than E) hence C_1 becomes negative showing a

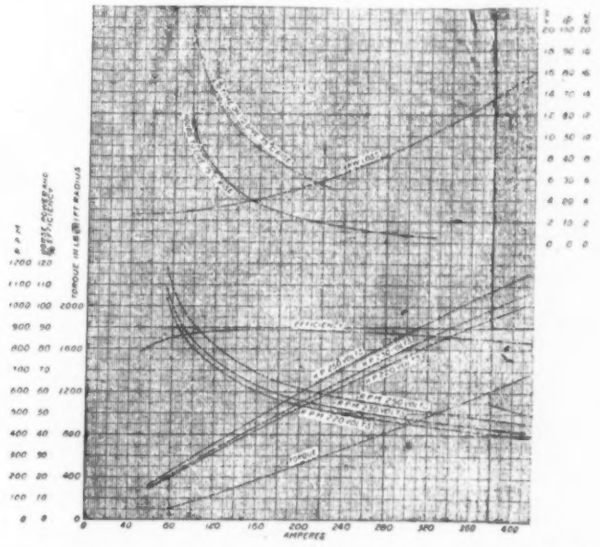


FIG. 6—Characteristic curves of the 85 HP-460 RPM half hour rated motor used in the calculations given in this paper.

reversed or generator current. When such is the case, $C_2 = C + C_1$ showing that armature No. 2 is taking all the line current plus the current generated in armature No. 1. Armature No. 2 then must produce sufficient torque to propel the load and drive armature No. 1 as a generator through the connecting shaft between the two motors.

The above calculation is therefore self proving as if correctly done the algebraic sum of C_1 and C_2 will be equal to C and if they do not check a mistake must have been made in the calculation.

In testing for a condition of this kind ammeters can be put in the line and the two armature circuits and simultaneous readings taken. Care must be taken to know the polarity of the ammeters and this can easily be checked by noticing the kick of the needle when the controller is jogged to the first point and back to the off point with the motors stationary. Under this condition both motors take motor current and the needle deflection

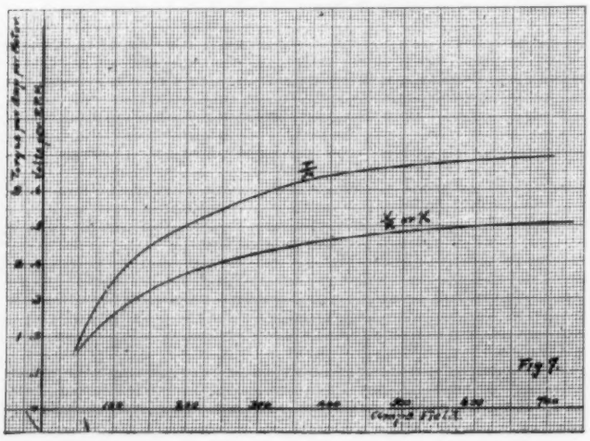


FIG. 7—Curves showing torque per ampere and volts per revolution (K) plotted against field current for the 85 HP. motor whose characteristic curves are given in Fig. 6.

can be determined for motoring and generating currents.

Cases may arise where the field circuit resistances are unbalanced and the armature circuit resistances are balanced in which case formula (1) becomes,

$$S = \frac{2E - Cr}{K_1 + K_2} \qquad (8)$$

Where all letters represent the same quantities as in (1) and r is the resistance of one armature circuit only. While it can be readily seen that unbalanced fields cause more trouble than unbalanced armatures, the speeds and currents can be calculated for this condition also and formula (1) becomes,

$$S = \frac{E\ (r_1 + r_2) - Cr_1\ r_2}{K\ (r_1 + r_2)} \qquad (9)$$

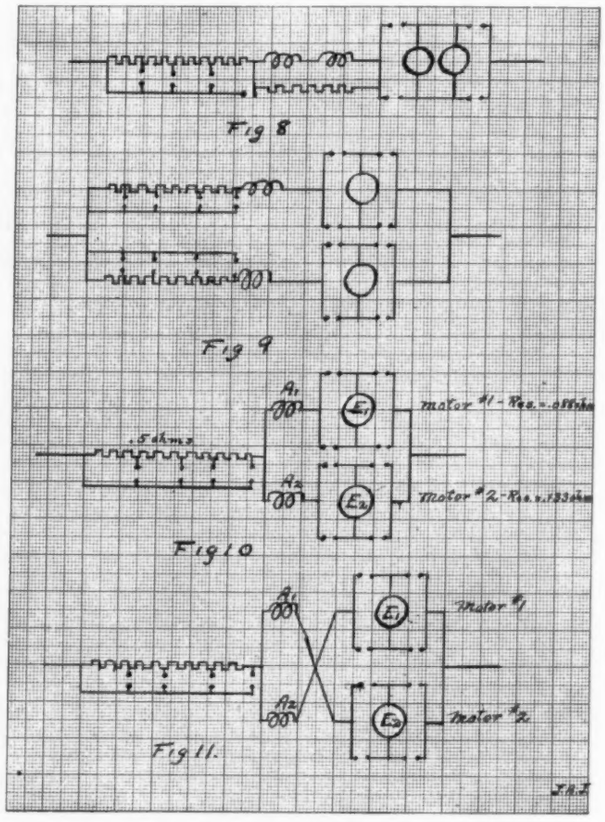
The torque in either motor for either motor or generator current can be determined by multiplying the current in the armature by the value of $\frac{T}{A}$ for the current in the corresponding motor field, the curve in Figue 7 being used to determine $\frac{T}{A}$ for the particular field current under consideration.

Other Control Connections

Figures 8 to 11 inclusive show other connections sometimes used with two series motors in parallel and these connections as well as the one shown in Fig. 1 will now be briefly analyzed.

In Fig. 8 the two fields are connected in series and are paralleled with a resistance of equal value so that each field gets the current for a single armature. This connection reduces unbalanced currents when either motoring or plugging, to an amount which is not objectionable even though there may be considerable difference in the lead resistances. Its principal disadvantages are the possibility of overheated fields if a grid breaks, extra power loss in the resistor and the fact that the resistances of the field coils and the grids will not vary uniformly with heat due to their different temperature coefficients and heat dissipating ability.

The connection in Fig. 9 gives very satisfactory operation as circulating currents are eliminated under all conditions of operation and in case of trouble on one motor or control, it can be quickly and conveniently isolated and operation can be continued on the



FIGS. 8, 9, 10 & 11—Various control connections which may be used for two series motors rigidly connected to the same load and subjected to plugging duty.

other motor and control. The only complication involved is the desirability of operating both sets of accelerating contactors from one set of accelerating relays to insure simultaneous contactor operation, smooth acceleration and the elimination of exchange torque strains in the cross connecting shaft.

Figure 10 is the same as Figure 1 except that the plugging resistance is taken out of the loop circuit and placed in the common line. Figure 10 gives quite satisfactory operation even with appreciable unbalancing of the two branches of the circuit so long as the motors are operating with a positive motor load. With the resistance of one branch 30

per cent greater than the other, the division of current is 45.5% and 54.5% for full load current and 48.8% and 51.2% for half full load current.

When plugging, operation is not only not satisfactory but is almost prohibitive as under this condition the motors become, in effect, two series generators and their C.E.M.F. adds to the line voltage instead of opposing it.

Under plugging conditions the voltage drop due to resistance across the two motors is small. For example, with .5 ohms plugging resistance and plugging from a speed which causes a line current of 1000 amperes to flow, the total voltage in the circuit must be 553 of which 230 is impressed from the line and 323 volts must be generated by the motors. However, the drop across the external resistance must be 500 volts leaving only 53 volts necessary to send the current through the motors. Thus this low voltage has little or no stabilizing effect so that the loop circuit contains two series generators short circuited on themselves—a very unstable combination.

Now if E_1 equals the C.E.M.F. and A_1 the current of motor No. 1 and E_2 and A_2 the voltage and current of motor No. 2, it is obvious that E_1 will be greater than E_2 as its field will be stronger due to the greater value of A_1.

The difference in the two voltages then sets up a circulating current in the loop which current flows with the line current in motor No. 1 and against it in motor No. 2. This action is accumulative as the increase in A_1 increases E_1 and the decrease or reversal of A_2 decreases or even reverses E_2. This action takes place almost momentarily and the torque becomes so great as to stop the motors almost instantly. By putting the plugging resistance only inside the loop as in Fig. 1, three-tenths of an ohm is added to each branch of the loop and the external resistance is reduced from .5 to .35 ohms to give the same plugging protection. Then with 1000 amperes flowing the resistance drop inside the loop circuit is increased from 53 to 203 volts which has a much greater stabilizing effect. Further the total resistance of the loop is increased from .221 ohms to .821 ohms, which reduces any circulating current which starts to flow to a small value.

A test made by the author on a crane bridge motion demonstrated very forcibly the speed of the accumulative action and the severity of the stop. On plugging, the truck wheels immediately came to a momentary standstill, started turning again due to the momentum of the crane, stopped again and repeated this about four times with decreasing amplitude until the crane was brought to rest. The time from plugging until the crane was entirely stopped was less than two seconds and the crane did not travel over three feet during the retarding period.

Figure 11 shows a connection which has been suggested to overcome the bad plugging condition as described above. The only trouble with it is that while it tends to stabilize the plugging condition, it makes the straight motor operation unstable although to a lesser extent. If we let E_1 and E_2 be the C.E.M.F of Motor No. 1 and Motor No. 2, respectively and A_1 and A_2 be the current in the fields of Motor No. 1 and Motor No. 2, respectively, and if we assume that the resistance of the two circuits is slightly unbalanced so as to make A_1 larger than A_2: then E_1 will be larger than E_2 as speed is same on both motors and the flux of Motor No. 1 is stronger. As the speed increases during acceleration the tendency is for E_1 to continue to increase, which in turn reduces A_2 which in turn decreases E_2 causing a further increase in A_1. This again increases E_1 and the cycle is thus accumulative to a point where A_1 becomes so great as to open the overload protection. This action is not as sudden as the accumulative action when plugging as the voltages which cause it are much smaller and it is possible that motors using the connections in Fig. 11 may not cause noticeable trouble if operating for only short intervals where most of the work is acceleration such as frequently occurs on crane bridge and trolley motions. The unstable tendency is there, however, and if left running long enough, trouble would start.

*The Automatic Control of Synchronous Motors**

By J. H. HALL†

DURING the past ten years, automatic control of Induction Motors has been used extensively owing to the following well recognized advantages: Increased economy of operation; convenience of installation; greater safety to the operator and to the electrical equipment; and the simplicity of control obtained by pressing a start and stop push button. Further advantages of electrical interlocking are possible for a number of motors driving material handling apparatus, where sequential starting and stopping is desirable.

It has been erroneously understood by many users that supervisory starting of synchronous motors is necessary, and the practice of using manual control has continued. The development of reliable automatic starting equipment has made it possible to secure for synchronous motors all the advantages of automatic control mentioned above, aside from the consideration of slow speed operation of direct connected units, and the desirable feature of power factor improvement. Moreover, the improvements in design, tending toward the development of satisfactory starting torque, has given the synchronous motor a high standing for general purpose applications.

A synchronous motor, unlike a squirrel-cage, or a slip-ring, induction motor, has a direct current field winding, and the control, in starting, therefore involves one more operation; that of exciting the field winding at the proper time. It is common practice to connect the field winding, during starting, in a

*Presented before Birmingham Section, March 26, 1927.
†Engr., Electric Controller & Mfg. Co., Cleveland, Ohio.

closed circuit containing a resistance. This circuit is closed when the field is disconnected from the D.C. line, when the motor is stopped, to allow the field to discharge, thereby preventing undue voltage strains on the insulation of the field. Starting with

FIG. 1—Installation of 100 H.P., 440 V., 3-phase, 60-cycle, No. 2 synchronous motor starter. Andrews Steel Company.

a closed field circuit also reduced the voltage strains which would otherwise be induced at the field terminals. The closed field circuit, during starting, also performs an important function in the modification of starting torque, which will be referred to presently.

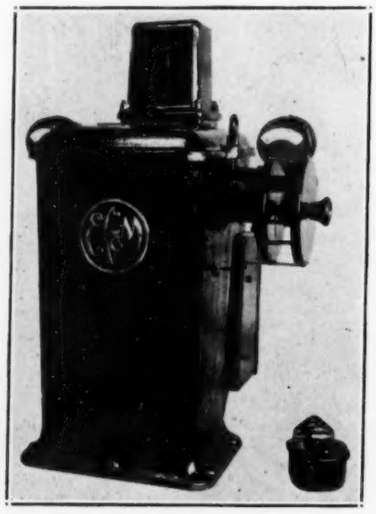


FIG. 2—Exterior view 200 H.P., 440 V., 3-phase, 60-cycle No. 3 synchronous motor starter. Andrews Steel Company.

The self-starting synchronous motor has on the field pole-pieces an amortisseur, or cage, winding to bring the motor up to speed as a squirrel-cage motor. Some makes of synchronous motors have solid cast iron pole shoes in which eddy currents circulate to produce a like result. At synchronism, the motor field pole pieces are locked opposite the revolving polar sections of the stator, hence, no alternating flux passes across the amortisseur windings, leaving them inactive during the running period, except as a damping device for reducing hunting. During the starting period, the torque of a synchronous motor may be considered as comprising two components,

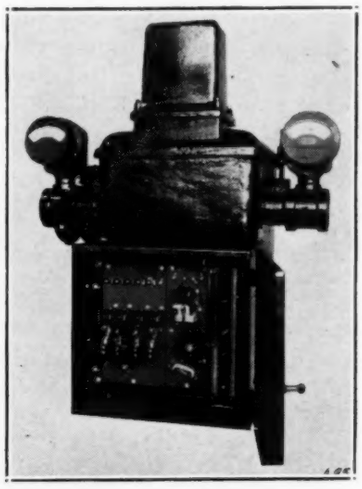


FIG. 3—Same as Fig. 2 showing interior view of cabinet containing field switching device.

one resulting from the cage winding, the other from the closed field winding.

The starting torque developed by the **cage winding** can be made high or low to suit the character of the load by the use of a high or low resistance cage winding. There is this difficulty, however, that the

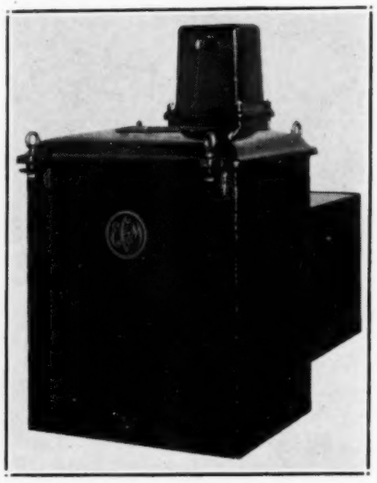


FIG. 4A—Exterior front view 125 H.P., 2200 V., 3-phase, 60-cycle No. 10 synchronous motor starter.

cage winding which gives a high starting torque will have a low pull-in torque. If a high pull-in torque is desired, it can be had at the expense of a low starting torque.

The torque developed by the **closed field winding**, during starting, depends to a certain extent upon the

value of resistance included in the circuit and therefore can be modified by changing the value of the field discharge resistor. Although the increasing of the resistance in the field circuit will increase the torque at starting, it usually requires a certain definite intermediate value of resistance in this circuit to secure maximum pull-in torque. The ability to thus change the torque characteristics of the amortisseur winding and the field winding, enables the synchronous motor builder to design a motor which will meet nearly all load conditions in starting, including those that require a high starting torque, as well as those that require a high torque when the motor pulls into step.

The combined starting torque of the two windings is effective up to approximately 95% of synchronous speed, when it begins to decrease rapidly to zero, at synchronism. A motor without load will sometimes lock into step without the D.C. field being energized, but a motor, even slightly loaded, requires the connection of the field to the D.C. supply to pull the motor into step. This should take place at the speed **nearest synchronism** that the combined starting torque will operate the connected load.

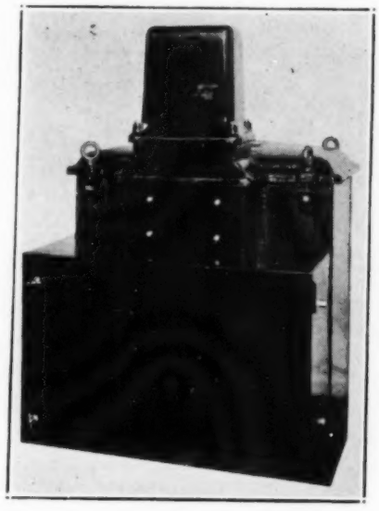


FIG. 4B—Exterior rear view 125 HP., 2200 V., 3-phase, 60-cycle No. 10 synchronous motor starter.

When the armature, or stator, is connected to the supply circuit, a revolving field is established in the stator which induces a current in the closed field circuit. The induced current in the closed field circuit has a frequency equal to that of the line at the moment of starting, and gradually diminishes to zero at synchronism. The induced voltage impressed on this circuit also diminishes from a maximum at starting to zero at synchronism. This has the effect of maintaining a constant current value of diminishing frequency in the field circuit until very near synchronism, when the current value reduces to zero.

From these considerations, it is evident that the switching of the field circuit should occur at the moment at which the pull-in torque has accelerated the load nearest to synchronism, which is approximately 95% of synchronous speed. The field contactor, in operating, opens the closed field circuit and connects the field winding to the D.C. supply. A field rheostat is included in the field circuit, when connected to the D.C. supply, to permit the adjustment of the field excitation to give the desired power factor correction.

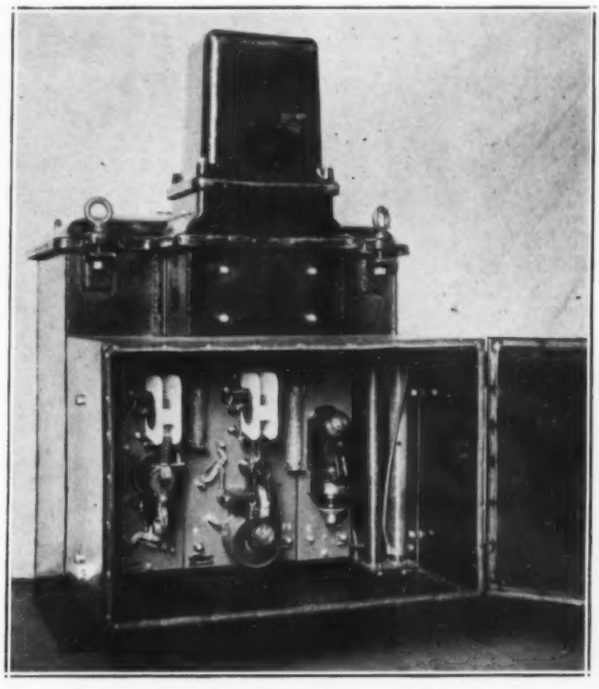


FIG. 5—Same as Fig. 4 showing interior view of cabinet containing field switching device.

While discussing the field switching, it may be interesting to describe several of the methods in use for closing the field contactor automatically at the proper moment. The devices used are electrically interlocked so as to function after the stator switching is completed. The devices more frequently used are as follows:

FIG. 6—Installation of 100 H.P., 2200 V., 3-phase, 60-cycle, No. 10 synchronous motor starter. U. S. Aluminum Co.

(1) **Time Relay:** This relay allows a sufficient time to elapse, after the stator is connected to full voltage, for the motor to accelerate to its maximum

speed, at which time it operates to close the field contactor.

(2) **A Field Contactor** having two opposing windings, (a) a shunt winding connected to the line tending to close it and (b) a series winding in the closed field circuit tending to hold it open. This contactor operates, when the field current diminishes to a low value, and connects the field to the D.C. line.

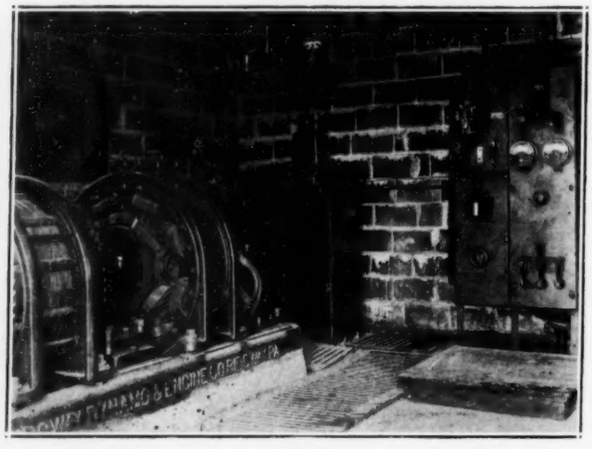


FIG. 7—Installation of 300 H.P., 2200 V., 3-phase, 60-cycle, synchronous motor starter for automatic substation at Bulger Block Coal Co.

(3) **Frequency Relay:** The winding of this relay is in shunt with a reactor connected in the closed field circuit. As a result of the high frequency of the induced field current at the beginning of the starting period, a greater portion of the current flows in the shunt path containing the relay winding, and

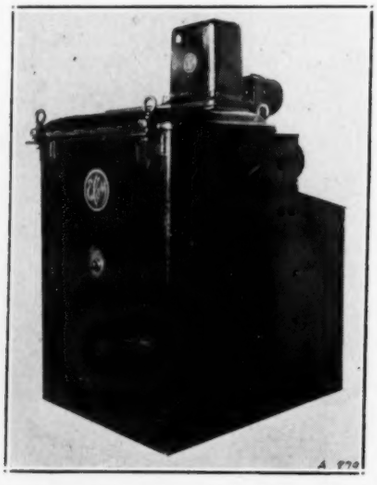


FIG. 8—Exterior rear view of 350 H.P., 2200 V., 3-phase, 60-cycle synchronous motor starter. Lehigh Portland Cement Co.

its contacts are held open. The relay winding is energized until the frequency reduces to a low value near synchronism, at which time its contacts close and energize the operating coil of the field contactor.

Synchronous motor starting equipment therefore involves the A.C. switching apparatus for the stator, the D.C. switching apparatus for the field, an adjustable rheostat for the motor field, and usually a number of indicating or recording instruments of various combinations for both circuits. In order to make use of standard equipment, the practice in the past has lead to the use of the switchboard type of control apparatus, which requires considerable space and a location free from dust.

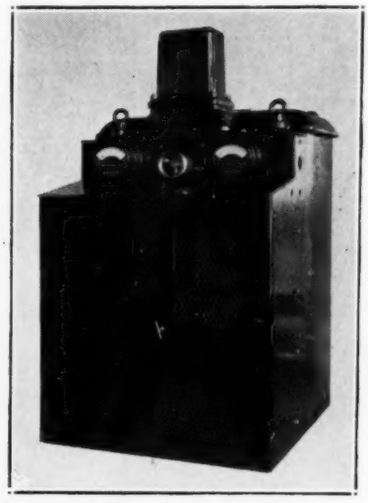


FIG. 9—Front view of Fig. 8

In steel mills, cement mills, coke and sintering plants, boiler houses, and other plants where fine dust is prevalent in the atmosphere, it is difficult to keep the dust out of separate control rooms, or even from a separate building sometimes erected to house the control equipment. Dust conditions are practically the same in the control rooms of such plants, as they are in the mill itself.

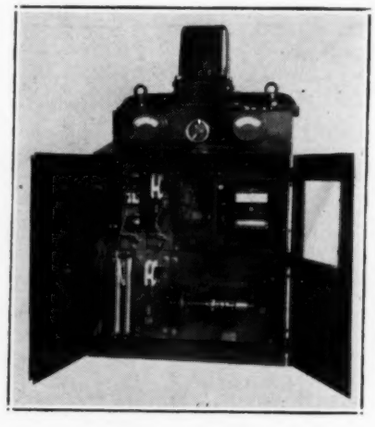


FIG. 10—Same as Fig. 9 showing interior of compartment containing field switch, automatic clutch controller and feed motor regulator.

Some ten years ago, a completely oil immersed type of automatic compensator for squirrel cage motors, that can be installed in the mill and located near the motor, was developed and placed on the market. This compensator was designed to meet the most exacting conditions of dirt, dust, and severe service. The adoption of the same unit type self

contained form of automatic starting equipment has proven to be of inestimable value for starting synchronous motor. The apparatus is entirely enclosed and can be mounted near the motor for individual installation, or in a control room for a group of motors. The entire equipment comprises a single piece of apparatus arranged for floor mounting thoroughly protected against moisture and dust. The A.C. equipment, including the contactor mechanism, transformers, and current limit relay, is contained in a steel tank and completely submerged in oil. The tank has a cast iron cover, and the O.L. relays are mounted above the oil and enclosed by an auxiliary cover.

The D.C. field switching apparatus is enclosed in a dust-proof compartment, forming an integral part of the unit, with provision for mounting, indicating, integrating, or recording instruments as desired. For **small** motors the field rheostat can be

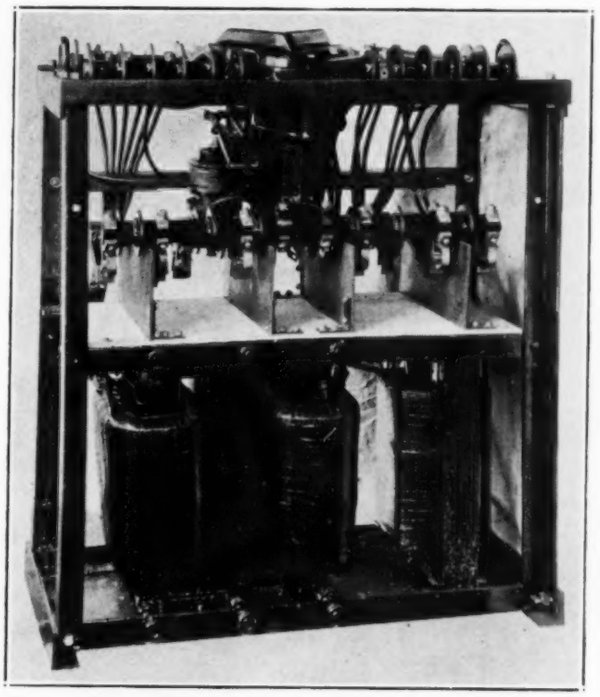


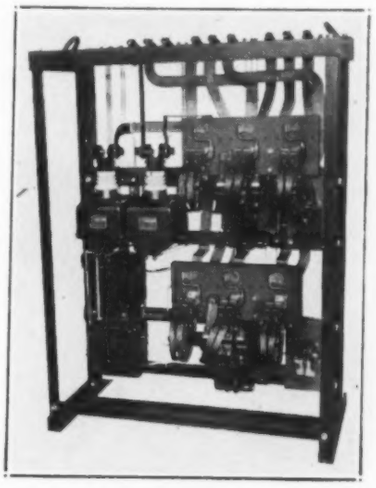
FIG. 11—125 H.P., 2200 V., 3-phase, 60-cycle, No. 10 reduced voltage compensator mechanism.

mounted self-contained. For the **larger** motors, the field rheostat is of such large dimensions that it is mounted separately, but it can be adjusted by a rheostat handle conveniently mounted on the unit-type starting equipment.

In oil refineries, chemical plants and steel plants where operating atmospheres contain corrosive fumes or explosive vapors, the field panel can be supplied with the field contactor and relay oil-immersed. This is usually supplied as a separate unit. Provision has been made for furnishing the overload panel contacts oil-immersed, for explosive atmospheres, and for completely submerging the overload panel, for atmospheres containing corrosive fumes. For these unusual conditions the entire control equipment is completely oil-immersed.

OPERATION

Since the starting of a synchronous motor is similar to that of a squirrel-cage motor, a standard automatic compensator is used to connect the stator to the A.C. lines, with an auto-transformer to provide the reduced voltage at starting. The com-



No. 12—350 H.P., 550 V. Resistor Type Reduced Voltage starting mechanism.

pensator operates with current limit acceleration to connect the motor to full voltage at about 75% of the synchronous speed of the motor. On 2200 volt compensators the continuous torque method of transition is used, in which the motor is not disconnected from the line during the switching operation. The automatic field switching device electrically interlocked with the Compensator, operates to open the

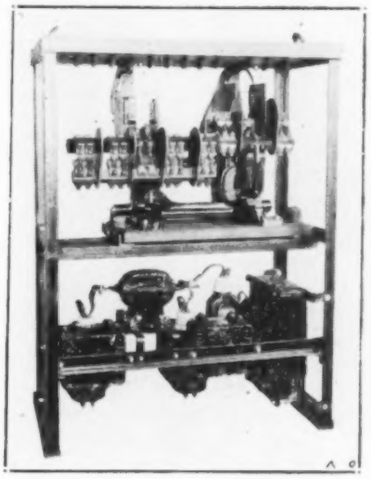


FIG. 13—500 H.P., 2200 V., 3-phase, 60-cycle Across-the-line type starting mechanism with instrument and potential transformers.

closed field circuit and connect the field to the D.C. supply at about 95% of synchronous speed. The D.C. excitation of the field effects the final step of pulling the motor into synchronism. The entire operation takes place automatically and is controlled from a single start and stop master switch.

Primary resistor type of reduced voltage starting is sometimes substituted for the compensator type, the automatic operation being otherwise the same.

Slow speed synchronous motors, as compared with high speed synchronous motors or squirrel-cage motors, have a low current inrush if started on full voltage. Where the conditions are such as to permit it, slow speed synchronous motors are started across the line. In this case the compensator is replaced by an across-the-line starter in connection with the field switching device and the necessary electrical interlocks.

SPECIAL FEATURES

Clutch Control: When Crushers and Grinders requiring a heavy starting torque are driven by synchronous motors it is the custom to provide a magnetic clutch between the motor shaft and the driven

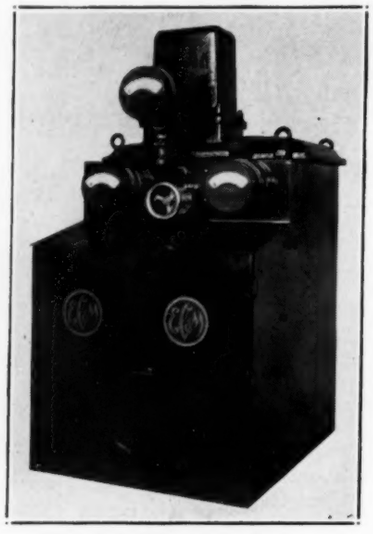


FIG. 14—Exterior front view of 75 H.P., 2200 V., 3-phase, 60-cycle starter for motor generator set.

shaft. This allows the motor to be started light, requiring a smaller amount of power during the starting period. After the motor has been synchronized, the load shaft is started by energizing the clutch, the motor then having available for starting the load, its maximum pull-out torque. The use of a clutch also permits the load to be stopped without stopping the motor, the motor continuing to run as a synchronous condenser for power factor correction. Synchronous starters can have incorporated in the self-contained unit, a clutch controller, interlocked with the starting equipment, so that the clutch cannot be energized until the motor is up to speed and its field energized.

For **small** motors operating with a clutch, a single contactor controlled by a separate push button can be used for energizing the clutch. For the **larger** motors, a resistor is inserted in series with the clutch, and cut out by means of a time limit device, or a motor-driven drum controller, for gradually increasing the energization of the clutch. This has the effect of introducing a time element for bringing the load shaft up to speed, thereby keeping the motor current at a lower average value during the starting of the load itself.

Feed Motor Control: On certain types of Crushers, such as the Bradley Hercules Mills, a small squirrel-cage motor operates a device for regulating the feed of the material entering the Crusher. Ma-

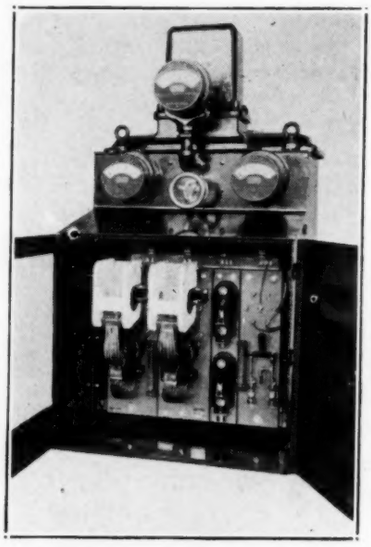


FIG. 15—Same as Fig. 14 showing interior of compartment containing the main direct current switchboard panel.

terial is fed to the Crusher only while the feed motor driving that device is running. A special current relay, equivalent to a contacting ammeter, controls the starting and stopping of the feed motor to maintain a constant load on the crusher motor, in exactly the same manner as a pressure regulator controls a pump motor to maintain a constant value

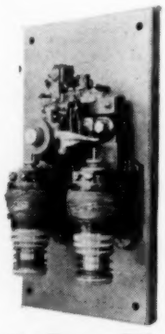


FIG. 16—Type ZM inverse time element over load panel.

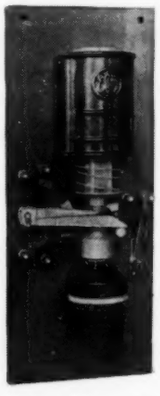


FIG. 17—Type HG mercury time relay.

in a pressure system. The load on the synchronous motor is thus kept at approximately full load, the feed motor stopping when the load on the crusher motor is about 3% above normal and starting again when the load has diminished to about 3% below normal. The feed motor control is interlocked with the clutch control so that the clutch must be fully

energized before the feed motor can start. The feed motor regulator panel can also be enclosed in the compartment containing the field switching device.

PROTECTIVE DEVICES

No-Voltage Protection: The control circuits are arranged so that the motor must be restarted from the master switch after failure of A.C. voltage or overload.

D.C. Voltage Failure Relay: In systems using a separate D.C. source for the field, a relay is used with its winding connected across the D.C. lines and its contacts connected in series with the operating coil of the Compensator, or the Across-the-line contactor, if used. This prevents the operator from attempting to start the motor unless the D.C. supply is available.

Overload Device: The overload relay coils are in circuit during the starting and running period.

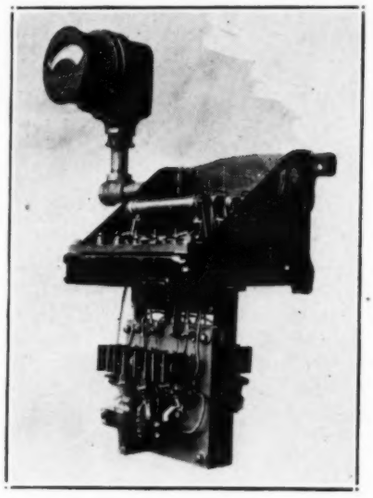


FIG. 18—Oil-immersed field switching panel with covers removed.

They are usually adjusted to operate on 125% of full load current to protect the motor during the running period, and they have sufficient time element to allow the motor to accelerate with the higher current value during starting. The magnetic circuit is so designed that for a given current value in the coil, a constant pull exists between the movable and stationary portions throughout the whole travel of the relay plunger. If the plunger is partially raised due to a short time overload, it will reset to its full time position again when the overload condition is removed.

With the standard setting, the overload device will operate to take the motor off the line under the following conditions:

1. (a) a sustained overload of 25%,
2. (b) heavy overloads of less duration,
3. (c) an attempt to start with one phase open,
4. (d) continued running with one phase open if the motor current in the remaining phases is above 125% of full load current,
5. (e) upon the failure of the motor to accelerate in a given time,
6. (f) upon the failure of the motor to pull into step,
7. (g) if the motor drops out of step,
8. (h) upon the loss of the D.C. field.

ELECTRICAL INTERLOCKS

On Standard Starters: With the D.C. voltage failure relay and O. L. relay contacts closed, after the master switch is operated, the field switch cannot close until the stator is connected to full voltage and the motor has accelerated to about 95% of synchronous speed.

FIG. 19—Exterior of oil-immersed field switching panel.

On Special Starters Noted Above: The clutch cannot be energized (from separate push button) until the field switch is closed.

The feed motor cannot start until the clutch is full energized.

The opening, or the failure, of the clutch circuit stops the feed motor.

Failure of A.C. or D.C. voltages, or the opening of compensator operating coil circuit from any cause, disconnects the stator from the A.C. line, deenergizes the field and the clutch and stops the feed motor.

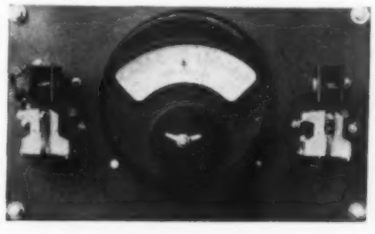


FIG. 20—Automatic Power Factor Regulator.

INSTRUMENTS

Provision can be made for mounting self-contained on the starter unit the following instruments:

A.C. line ammeter (with current transformer oil-immersed),
D.C. field ammeter,
A.C. and D.C. voltmeters if desired,
Recording or curve drawing wattmeters,
Field rheostats for small motors,
Hand wheel for operating field rheostat on large motors.

The synchronous motor control apparatus here described lends itself freely to the incorporation of such auxiliary apparatus as is required for the automatic starting of the motor, together with the necessary electrical interlocking for sequential operation with other motors, or for the provision of special features in connection with the motor equipment.

Exciters: The direct current supply for the field may be taken from an existing 125 or 230 volt D.C. shop line. When this is not available, the fields are supplied from an exciter driven by the synchronous motor, or from a separate motor-generator set. A group of synchronous motors are frequently supplied from a single motor-generator set, and the motor driving it may be a synchronous motor or a squirrel-cage motor.

In either case, the automatic starting equipment for the motor-generator set is of the oil-immersed type similar to that used for the synchronous motor. This may have incorporated in it and self-contained, such instruments as desired. The contactors for the D.C. supply busses, with overload protection, are mounted on the starting equipment in a separate compartment, the operation of the contactors being controlled from a master switch.

AUTOMATIC POWER-FACTOR REGULATION

In plants using a relatively large number of synchronous motors, where the power factor of the system is satisfactory, the tendency has been to install unity power-factor machines due to the lower cost.

Concerns using a large percentage of induction motors can profitably install one or more synchronous motors designed for power-factor correction, which will improve the power-factor of the whole system. If convenient, these motors are equipped with clutches to permit the operation of the motors as synchronous condensers when the driven load is disconnected. In such cases, it is desirable to control automatically the field excitation of the motor to maintain the power-factor of the machine, or of the system, within certain limits.

A recent development in automatic power factor regulation provides a simplified form of automatic regulators, which comprises a contact making power-factor meter and a pair of relays selectively operated by the contacts. This device automatically controls the operation of a motor-driven rheostat, which may be in the circuit of motor field, or of the exciter field. The electrical contacts on the power-factor meter are readily adjustable from the outside of the meter case, permitting the power-factor to be maintained between any desirable limits.

Entirely aside from the consideration of safety and simplicity of control, the self-contained totally enclosed type of construction for synchronous motor starters has been developed in response to demands from many steel plants where operating conditions are severe, and the problem of dirt and dust has been a difficult one to solve. Although the cost of the enclosed type of starter is somewhat greater than the open panel type, this is more than offset by an item which may be considered as insurance on: correct operation, continuity of service, and safety to workmen and to the electrical equipment. Furthermore, the cost of installation is greatly reduced. The synchronous motor starter herein described is completely wired so that the installation involves only the connections of the starter to the line, the motor and the master switch. The starter itself can be set down on the floor in the most available space. All exposed parts are electrically grounded so that enclosing gratings or protective guard rails are unnecessary.

DISCUSSION

W. W. Garrett*: Gentlemen, I am sure that I voice the opinion of this gathering when I say that we are indeed indebted to Mr. Hall for his most excellent paper. This has been a paper into which a great deal of thought and study have been placed, and without some time for study on our part, I almost hesitate to open discussion in a casual way on a subject where so much study has been made. However, I would like to ask Mr. Hall what is the assembled weight of one of his 300 HP. Starting units?

J. H. Hall†: The net weight of a 300 HP., 2200 volt, 3 phase, 60 cycle complete synchronous motor starter of the type shown here is approximately 3100 pounds, including the oil.

J. E. Harrell‡: Is it not necessary to work with Motor Builder to get complete data so that you can furnish the proper equipment?

J. H. Hall: In many cases the synchronous motor is designed to meet the particular torque requirements of the application, which may be unusual at starting or at pull-in. Since the resistance of the field circuit affects the performance in starting, the field discharge resistor is usually designed and furnished by the Motor Builders. The only other information needed by us is the line characteristics such as voltage, phase, and frequency, the KVA capacity of the motor, and the field voltage and current; also whether the field is separately or self-excited.

A. L. Lemon§: Some manufacturers of synchronous motors require that the field be short circuited while others require that it be left open while starting. Is it necessary for you to get in touch with the Motor Builder before making up a starter, or will the starter as you make it meet either of the above conditions?

J. H. Hall: A synchronous motor started with the field completely short circuited develops its minimum starting torque and minimum pull-in torque. With the field circuit opened, the motor develops its maximum starting torque and a somewhat higher pull-in torque, than in the case of a short circuited field. This method of starting is seldom practiced, however, because the induced voltage at the field terminals may be as high as 3000 or 4000 volts, depending upon the number of poles on the motor. This high voltage is a source of danger to the field insulation and the operators or attendants.

We recommend in all cases that the motor be started with the field connected in a closed circuit

*Bureau of Tests, Elec. Dept., Tennessee Coal, Iron & R. R. Co., Fairfield, Ala.

†Engr., Electric Controller & Mfg. Co., Cleveland, Ohio.

‡Tennessee Coal, Iron & R. R. Co., Birmingham, Ala.

§General Machinery Co., Birmingham, Ala.

including a resistor, to eliminate the voltage strains on the field insulation. A resistor can be selected which will give practically maximum torque in starting and there is, with most motors, a certain resistor value which will develop, at pull-in, a torque value which exceeds the pull-in torque with a completely shorted field or with an open field.

If the Motor Builder furnishes the proper motor and determines correctly the field discharge resistor to cover the starting and pull-in requirements of the load, the switching of the EC&M starters will effect the correct starting of the motor. If the starting characteristics of the load are indeterminate, it is frequently necessary to make slight changes in adjustment of the field discharge resistor when the motor and starter are installed. For this reason, the field discharge resistor should be arranged with adjustable taps to secure the best starting performance. If the motor will not develop sufficient torque to start the load without actually opening the field circuit, we would prefer to have this knowledge before furnishing the controller, in order that provision can be made for this unusual field switching.

A. L. Lemon: You spoke about time relay, how about the risk of damage to control if circuit breaker does not operate?

J. H. Hall: The time relay determines the time between the connections of the motor stator to full voltage, and the energization of the D.C. field. On reduced voltage starters this seldom exceeds 6 or 8 seconds. The overload device furnished on the synchronous motor starters is the same type as supplied with standard automatic compensators for squirrel-cage motors and is effective during the starting and running periods of the motor. The inverse time element feature of the overload device is ample to take care of the high starting current and provides the usual 25% overload protection to the motor during the running period. The starter will open successfully any excessive current on the order of starting currents in the event that the motor refuses to start or takes an excessive time to accelerate, and the time element feature of the overload device allows the circuit breaker on the feeder to open short circuit currents thereby protecting the starting equipment from any risk of damage.

A. L. Lemon: Do you make any provision for releasing gas from the Compensator Case?

J. H. Hall: To allow for the escape of gases and to relieve excess pressure inside of the case, a breather pipe is provided on the cover with an opening vertically downward, so arranged to prevent the entrance of dirt and moisture. Since the case or tank is completely filled with oil, there is a relatively small air space above the oil.

W. W. Garrett: Could I use your automatic power-factor control in connection with a synchronous driven motor-generator set to regulate the power factor of an A.C. system?

J. H. Hall: Providing the synchronous motor has sufficient power-factor corrective capacity, the power-factor of the system can be maintained as desired between very close limits.

J. E. Harrell: On your standard Compensators what voltage taps are provided?

J. H. Hall: On EC&M standard Automatic Compensators as well as on Synchronous motor starters, the reduced voltage taps are 50%, 58%, 70% and 85% of normal voltage.

J. E. Sayre*: Suppose I had a 250 HP. synchronous motor and wanted to change to another motor of different size, what changes would you have to make on your equipment?

J. H. Hall: To change a 250 HP. synchronous motor starter for a motor of smaller capacity of the same voltage, phase, and frequency, a new series transition relay coil and the overload operating coils would be required. For a motor of larger capacity new auto-transformers would also be required of the proper capacity.

W. W. Garrett: What is the time element of the field contactor after the motor is on full voltage?

J. H. Hall: On reduced voltage starting, the motor is up to about 75% of synchronous speed when transition takes place from reduced voltage to full voltage on the stator circuit. The time required to accelerate the motor from 75% speed to synchronous speed is in most cases not more than 6 to 8 seconds. For across-the-line starting, the time required to accelerate the motor from zero speed to synchronous speed varies from 6 seconds to 2 minutes, depending upon the torque characteristics of the motor and the fly-wheel effect of the rotor and load.

G. H. Finks†: What kind of a time limit relay do you have on the automatic power-factor meter?

J. H. Hall: There is no time limit relay on the automatic power-factor regulator. The pilot motor-driven rheostat which is controlled by the regulator has a certain time period in operating from one contact to another. Let us say the meter hand engages the left fixed contact on the meter; the pilot motor operates the rheostat to change the power-factor until the meter hand disengages the fixed contact, whereupon the pilot motor stops. If the power-factor of the system changes so that the left contact is engaged again, the pilot motor moves the rheostat again in the same direction. If the power-factor of the system changes so that the meter hand engages the right fixed contact, the pilot motor operates in the reverse direction and changes the field circuit in such a way as to cause the meter hand to leave the right fixed contact, whereupon the motor stops again. Thus the power-factor on the system is maintained between the values of the fixed contacts of the meter which are adjustable.

G. H. Finks: How close is meter set? Could meter be set at 95% leading and 95% lagging power-factor?

J. H. Hall: Yes, we can do better than that. A regulation of 3% above and 3% below the given value can be maintained; for example, the contacts can be adjusted at 97% leading and 97% lagging values and the regulator would maintain the power-factor of the system between these two limits, providing, of course, the synchronous motor has ample power-factor corrective capacity.

---

*Elec. Dept., Tennessee Coal, Iron & R. R. Co., Birmingham, Ala.

†Alabama Power Co., Birmingham, Ala.

Discussion: Electrical Development Committee Report*

By MEMBERSHIP

A. F. Kenyon†: Along the line of improved practice in rolling mill operation, may be mentioned the record breaking tonnage produced on the 40" reversing blooming mill at the Indiana Harbor Plant of the Inland Steel Company during March, 1927. 104,450 gross tons of ingots were rolled by this 40" mill during this one month. To my best knowledge this tonnage is in excess of that produced on any other electrically driven blooming mill during a similar period. The mill is driven by a 6500 H.P. continuous rated, double unit reversing motor, and has been in operation since 1917.

Mention was made in the committee report of the extremely short time required for the change-over from steam to electric drive on a 24" reversing sheet bar mill at the Inland Steel Company. No less remarkable was the similar change-over from steam to electric drive on the 36" reversing blooming mill during the same week in this same plant, and which involved work of much greater magnitude. The blooming mill change-over, involving removal of steam engine and piping weighing 400 tons, removal of 225 cubic yards of old engine foundations, placing forms and pouring 120 cubic yards of concrete in new foundations, and assembly, connection and testing of the 7000 H.P., 700 volt, 50/120 R.P.M. single unit reversing motor, weighing 225 tons, was accomplished in 147 hours, or 25 hours more than that required for the smaller 3000 H.P. drive. The time of shutdown required to electrify an old steam driven mill is a very important item when considering plant improvements, and we are indebted to the Inland Steel Co. for showing what can be done along this line.

R. S. Shoemaker‡: In our committee's report the rotary converter is conspicuous by its absence in furnishing power for these large direct current units. Manufacturers tell us that a 60-cycle machine is reliable in every way and has a cheaper first cost and higher efficiency. Why has it not meen applied as a prime mover for these large direct current units?

W. H. Burr§: Mr. Shoemaker is correct that it is conspicuous by its absence.

O. Needham:** Steel Mill Electrical Superintendents quite generally prefer motor generator sets. They have real reasons for this, in that most of them need power factor correction, which they can easily get with motor generator sets. Of course, the addition of rotary converters tends to improve the power factor of the system as they represent additional unity power factor load. They do not, however, supply any corrective capacity. Many installations need corrective capacity and it can easily be obtained by the use of leading power factor synchronous motor generator sets.

The question of voltage control also has its influence as it is quite easy to control the D.C. voltage of a motor generator set. Inherently a motor generator set requires lower maintenance than a rotary converter and will probably stand a little more abuse. This also has probably had something to do with the attitude of many steel mill operators in preferring motor generator sets. 60 cycle rotary converters have not been developed as rapidly as motor generator sets—in fact, in the higher capacities they are a comparatively recent development.

Rotary converters have higher efficiency than motor generator sets and there is no reason why they will not perform the service satisfactorily when correctly applied. They have been successfully used for many years in railway work—in fact there are a number of installations in steel mills that are entirely successful. A study of any individual installation will show which type of unit is the more economical and desirable, and either will successfully perform their service.

D. M. Petty*: I do not know whether Mr. Shoemaker has tried to start an argument or not, but if that is his intention, it is likely to be successful. Speaking of things being conspicuous by their absence, it has occurred to me that in view of the fact that some of the recent installations on reversing mill drive has been made with synchronous motors, that possibly the fly wheel is not needed any more. It seems to me a matter of working out the best possible potential system to do it.

A. J. Standing†: We have operated on 25 cycle, two 2000 K.W. converters and five 500 K.W. in steel mill power house and sub station work. At the expiration of the first five years we had tranformer trouble, but since then we have had no failure occur and have had no more maintenance on those machines than we have had on some m.g. sets. They have been able to stand plant surges, and the operation in every respect has been entirely satisfactory.

W. H. Burr: Record of 25 cycles is pretty good.

H. A. Winne‡: In the past year the Colorado Fuel and Iron Company has put into operation the electrical equipment on several mills. Three of these mills have direct current motors which are supplied with power from three 1600 kw. 600 volt 60 cycle converters and, so far as I am aware, the operation has been entirely successful. The d-c. ends of the converters are tied directly to the magnetic control panels for the motors with no d-c. circuit breakers or

*Presented at Annual Convention, June 13 to 18, 1927.

†General Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

‡Supt. of Maintenance, American Rolling Mills, Middletown, Ohio.

§Elec. Supt., Lukens Steel Co., Coatesville, Pa.

**General Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

*Elec. Supt., Lehigh Plant, Bethlehem Steel Co., Bethlehem, Pa.

†Elec. Supt., Saucon Plant, Bethlehem Steel Co., Bethlehem, Pa.

‡Engr., General Electric Co., Schenectady, N. Y.

knife switches between. In the past year the Inland Steel Company at their Indiana Harbor plant has also put into operation a d-c. motor drive, power for which is furnished by a 2200 kw. 25 cycle 600 volt converter. While, as a general rule, I think the motor generator is preferable to the converter for furnishing power to main roll drives, there is no question about the successful operation of the rotary converter as a direct current producing apparatus on either 25 or 60 cycles.

W. H. Burr: Have you any figures on comparative efficiency of the two units?

H. A. Winne: The overall efficiency of a motor generator of the size usually employed to furnish power to main roll drives is in the neighborhood of 90%, and where the incoming power is not more than 13,200 volts the motor generator can use this power direct, thus entailing no further losses in transformers. The full load efficiency of a synchronous converter and transformer, taking into account only the losses in the appratus, would probably be around 93% or 94%. There is, however, an item of loss which is usually overlooked in converter installations, and that is the loss in the heavy current buses between the transformer and the converter. The amount of this will vary depending upon the physical layout of the installation so it is impossible to give any figures.

A. F. Kenyon: With reference to the loading cranes at Homestead, the finished structural shapes are delivered to the shipping department at right angles to the railroad tracks. The loading cranes are therefore equipped with hoists hung from a revolving table, permitting the steel to be picked up, turned 90°, and then placed in the cars for shipment.

The crane controlled soaking pit covers are controlled through an arrangement of sectionalized rails. With four rows of pits, there will be four master controllers in the crane cab connected through the sectionalized rails to the four controllers which control the four pit cover motors. As the crane passes along the runway the master switches in the crane cab are successively connected to succeeding magnetic controllers, and hence the operator controls only the pit covers under the crane.

D. M. Petty: We installed a crane of that type. The crane is in operation and has been very satisfactory so far. We cannot expect any operating comparative data for four or five years, because we don't anticipate any trouble for that time at least. If it does not last that long we would be inclined to say it is a failure.

A. J. Standing: Last year the Superintendent of our Fabricating department and I looked around the country for better methods of handling work in our fabricating shops and around other ideas we developed a traveling wall jib crane which carries the electric rivet heater and the "bull riveter," the heater boy operates the crane and the heater. This makes a very economical unit. We have just completed the last of our cold saw feed drives, for 60" hot and cold saws for structural mill, replacing hydraulic feeds on the entire nine saws.

Geo. H. Schaeffer* I would like to make a remark about the use of electric magnets. It is a great labor saving proposition, especially with a big mill, but I want to tell you we got into a bad fix using electric magnets. We would load, say a steel truck and maybe pick the truck up with a magnet, then put on some finished bars; then somebody raises trouble about magnetizing the bars. If we put the bar through straightener, it will magnetize the rolls in the straightener, and probably we will have some particular job going through that straightener to be shipped and that will also be magnetized. Has anyone run into that same trouble?

W. H. Burr: Very frequently we load two or three plates that should not be loaded and they go to the wrong destination; and quite frequently, if not careful in handling material over scales, you will find serious discrepancies.

A. J. Standing: If Mr. Petty were here he might tell you that his merchant bar mill at the Lehigh plant has had some trouble with magnetized bars.

Frank W. Cramer†: The annual report of the Electrical Development Committee adds another chapter to the history of electrical progress in the steel industry. In these reports, the large installations usually furnish the most interesting data to record, while the small drives are only given passing notice.

During the past few years, there has been a marked tendency to replace line shafting with individual motor drives, and our historical files will not be complete without some reference to these changeovers. For example, the modern roll shops now have a motor for each lathe instead of a large motor driving a line shaft, machine shops are also being equipped with individual drives. On the modern wire drawing mills, each block is now a separate unit, and perhaps the latest step is the individual drives for run out rollers on mill tables. Each of these installations, it is true, are usually driven by a motor under 50 horse power, but if the total installations per year were compiled, the number of motors and total horse power would make a favorable comparison with the totals of the main roll drives.

I would suggest that the next report of the committee contain some data relative to the number of small motor installations.

S. S. Wales*: You have heard the report of the Electrical Development Committee, for which we thank Mr. Burr. This report should be very valuable in keeping us posted as to what has been done.

What might be classed as a new development or at least an improvement in the electric handling of material, has come up at the Ore Docks, at Conneaut Harbor within the last year.

During the ore season, any time that is lost in unloading or loading boats at the docks, is reflected in loss of tonnage brought down from Lake Superior, so that it is quite important to handle material as rapid as possible.

The coal car-dumper which loads boats for shipment to the Northwest was formerly a hand op-

*Elec. Engr., Carpenter Steel Co., Reading, Pa.

†Asst. Elec. Supt., Bethlehem Steel Co., Johnstown, Pa.

*Chief Elec. Engr., Carnegie Steel Co., Pittsburgh, Pa.

erated steam driven equipment, but has been changed over to full automatic electric operation, using all the old parts except the engine drive, and is now capable of unloading 50, seventy ton cars per hour, for which push button control is used, one contact starting a complete operation from clamping the car, hoisting, dumping, returning to the bottom, and unclamping.

The operator is provided with a hand controller which will allow him to interrupt and re-start the operation at any point. This, however, we expect to be very seldom used.

---

*Discussion: Fifteen Years of Steel Mill Illumination—What Change?**

By MEMBERSHIP

Ward Harrison‡: It is generally conceded that the Iron & Steel Electrical Engineers were the first group to consider illumination from a scientific basis. Back in 1910 to 1914, 16 papers were presented before this Association on the subject of light, and you might also say that scientific illumination started during that period. Nearly fifteen years have elapsed since then, and it occurred to me perhaps the best way to start off the subject this morning was to go back over those papers of which I had the privilege of giving about three.

One yardstick by which you might measure the efficiency of any manufacturer is whether the cost of the commodity he turns out is greater or less than 68 per cent over the pre-war figure. It might be interesting to remind you if you don't already know, how we will stand in that list.

About 15 years ago, the Association of Iron & Steel Electrical Engineers put the subject of electricity on its feet, and also interested itself in the subject of safety, and I think they also put that on its feet. As you go around steel plants today looking at them from a lighting standpoint, it is just as well to look at them from a safety standpoint.

A. J. Standing†: Mr. Harrison has more or less put the steel industry on trial. The subject of illumination came up at our Philadelphia section. We made an inspection trip through the General Electric Company's Lighting Institute at Harrison, N. J., where we went over the course of instruction, and a quantity of information put across in such a way that you can readily grasp its meaning. To me one outstanding feature was that where we talk about light as light, they stressed the fact that light is a raw product. It is illumination at the work that really counted, and throughout that whole day, stress was put on the proper illumination at the work in order to obtain best results from the standpoint of production and reduction of accidents.

In steel mill buildings we meet problems somewhat different from other industries. The nature of our buildings coupled with interference from overhead cranes; the dust and dirt in the atmosphere, and illumination or effect of our hot products on the general atmosphere, makes our problem somewhat different. Nevertheless we have no excuse to offer unless it be the fact that we lay too much stress in the cost of proper illumination.

D. W. Blakeslee*: Mr. Chairman and Gentlemen: We have the honor and pleasure of having presented before our convention a very able and valuable paper by one of the highest authorities on Industrial Illumination in the world. To those of us who have been interested in improving steel mill lighting during the past two decades the name Ward Harrison attracts our attention and holds our interest. He is well known to the most of us for his valuable papers presented before our Association fifteen years ago. They, more than anything else I believe, aroused our general interest to its maximum at about that time. Before that time in many works lamps had been hung here and there as they were thought to be needed, and there were few, if any, instruments in our plants for the measurement of illumination. Those of us who have tried to increase, or at least maintain, the general interest in the lighting of our works are very thankful to have again received the assistance and inspiration of Ward Harrison and we hope that the effect will be as good as, and more lasting than, his former co-operation by direct contact. If our interest in illumination has decreased during the past fifteen years we cannot blame Ward Harrison as he has been trying all this time to help us and he has helped those of us who have taken time to read the words of wisdom that flow from his prolific typewriter.

His paper this morning is of great value. Just to heart it read once is an inspiration, but to get its maximum value it must be read again and kept at hand, with his editorial in the June issue of the Iron and Steel Engineer, for reference. They should be used in the very near future as the time is now here when plans and designs should be made for adequate lighting systems which will provide illumination of such intensities as will permit maximum returns from the various shops, foundries, etc., in our works.

As most of us know, our State Codes prescribe minimum foot-candles of illumination for various industrial applications in an effort to reduce the great annual loss 108,000 man-years due to defective lighting installations. These State Codes were based upon the standards developed by the Illuminating Engineering Society to improve illumination of all

‡Director of Illumination, National Lamp Works, Cleveland, O.

†Elec. Supt., Saucon Plant, Bethlehem Steel Co., Bethlehem, Pa.

*Presented at Annual Convention, June 13-18, 1927.

*Formerly Electrical Engineer, Jones & Laughlin Steel Corporation.

applications by specifying their foot-candle intensities. In 1921 the American Engineering Standard Committee, from thirteen national organizations, approved the "American standard" code of lighting factories, mills and other work places.

Although it is well known that we are very much interested in the prevention of accidents (our organization was the father of the Safety-First movement) and that we try to conform to the lighting codes to prevent accidents, we should also be interested to as great an extent in the use of more illumination than required by the codes so that our stock-holders may realize greater returns can be obtained from the dollars spent in engineered lighting systems than from those dollars spent for any other one part of the works. Ward Harrison has shown us that an average of 15 per cent in average shop production may be obtained by an increase of two to eleven foot-candles of illumination. Of course by obtaining the maximum financial return through adequate illumination the accident hazard due to poor lighting is reduced to a minimum.

There is no danger of too much illumination from the safety point of view nor from any other viewpoint. Although our eyes could use it our electric lights for obvious reasons will never produce for general illumination the foot-candles received from the sun. Ward Harrison has shown us that we can now use sixteen times the illumination we had in 1912 without any increase in cost if we were using two foot-candles then we should not be using thirty foot-candles of illumination. We hope that no economical manager will imagine that he can save 15/16ths of his lighting costs by keeping the same level of illumination he had in 1912. If he has any such idea he should compare that cost with 15 per cent of the values of the production of his shops which might be obtained in addition if modern intensities were used.

As a guide to indicate desirable intensities in iron and steel works, the foot-candle illuminations of forty-two applications have been listed in a bulletin on "Lighting of the Metal Working Industries," issued by the Edison Lamp Works. Ward Harrison has simplified this by grouping the usual iron and steel applications under five heads; his recommendations are published in the convention isue of Iron and Steel Engineer, our official organ.

Ward Harrison has spoken of the great loss of illumination caused by dust and smoke which collects on the lighting equipment and of the great importance of keeping this equipment clean. In this connection there should also be considered the reflecting quality of the reflector and the effect of heat, dirt and cleaning upon its permanence as a reflector. He has also pointed out that the usual steel mill buildings have within them traveling cranes which, with other factors, cause high mounting of the lamps. Because of this high mounting, and since the walls and ceilings of the mill buildings are of necessity so dark that no light can be reflected from them, these buildings are best illuminated by use of a reflector which directs 70 per cent of the lamp lumens within a 60 degree zone upon the working plane.

In the lighting of a mill building, the size of the lamps, their spacings and locations are of as great importance as the selection of the design of reflector. Ward Harrison has given for our guidance general data on mounting heights and approximate spacings, for various representative areas, to obtain certain foot-candles with certain size lamps. It is believed, however, that time and money can be saved and more satisfactory results obtained by permitting an illuminating engineer who has had much experience in steel works illumination make the lighting layouts for the various specific applications. This is a service freely given by the reflector manufacturers and if a local manufacturer is consulted the design may be obtained in as short a time as if it were made in our works.

W. E. Miller*: Proper lighting in a steel plant is a big problem, due to the extensive areas to light, and interference from overhead cranes. It is further complicated by the smoke, gas, and dirt conditions which soon make the globes and reflectors inefficient, and necessitate frequent cleanings. Another factor is proper mounting, as there is usually considerable vibration to contend with, which if not taken care of will soon cause a failure in the lamp. In addition to this, there are still many mill lighting systems on the D.C. feeders where, during the week days, the line voltage is below normal, due to the line drop, and on Saturday nights and Sundays above normal when the mill load is decreased. These facts place the Electrical Superintendent in a compromising position.

When the installation is made, the electrical engineer tries to give what in his judgment is a good lighting job. After it is installed the operating departments, and often the various safety committees, look over the result and perhaps suggest certain changes and additions. Sometimes these additions are the result of individual prejudices rather than a necessity for more lights. After this stage of the work is passed, the next step is when the lighting costs start to come in. It is not only the number of K.W.H. consumed, but also the cost of cleaning and lamp replacements that make up these costs. These represent the economical side of the question, and then it may develop that lighting costs are too high in proportion to other costs. In other words, there is such a thing as overdoing the lighting jobs.

Another phase of the lighting question that has not been discussed this morning is floodlighting. We have recently experimented with this type of lighting around coke ovens where it is difficult to install good lighting with the usual type of lights. In these places, the interference of smoke, steam, dirt, and larry cars has to be overcome. On one such installation, it was possible to replace 32—200 watt lights with 4—750 watt floodlights, and secure better lighting than with the old system.

Thos. P. McGinnis†: My principle interest in this discussion is from the standpoint of floodlighting. I cannot see that we have reached a point in the development of general illumination of steel mills by Floodlighting that would justify saying very much here about it. Our experience so far has been more in the direction of oil refinery lighting. They seem to place a great deal more importance on projected illumination than do the steel mills, and this is partly because of the protection afforded by the location of electrical fixtures at a safe distance from the areas to be illuminated. Steel structures of adequate

*Supt. Elec. Dept., Bethlehem Steel Co., Johnstown, Pa.
†The Pyle-National Company, Chicago, Ill.

height are erected at advantageous locations to permit proper distribution of light.

Steel mills have made a starting in the Chicago District in the direction of general illumination by floodlighting. Of course, they have always made use of floodlighting for illumination where no other form of lighting would quite fill the bill, but have not yet arrived at the point of adopting projected light as a permanent means of illuminating all of the plant areas.

We are hoping within the next year, and possibly before the end of this year to make some installations in steel mills of the Chicago District which will offer an opportunity to make a study of the economies and effectiveness of general ilumination in the steel plants. It is possible that a report will be made of one of these installations before the Chicago Section of the Association by the end of this year, and we will try to present such data on distribution, intensities, and efficiencies as will be of real value to members of the Association in estimating the extent to which they will be justified in adopting these developments.

I am sorry there isn't any more to be said at this meeting, but I would like to hear from such members as may be interested, as to what their opinions are now compared with the opinion of one Illuminating Engineer from the Pittsburgh District who presented an article through the "Iron and Steel Engineer," saying that Illumination by Projectors was not satisfactory for the reason that the Reflectors were not capable of standing the heat of the lamps when turned sharply downward as is necessary in illuminating areas at short distances.

These opinions are desired to determine the extent to which development in Reflector and Projector design has been noted by the various Electrical and Iluminating Engineers of the Steel Plants and kindred industries.

A. J. Standing†: We have found in connection with crane problem that high bay lighting makes it light enough to repair the cranes and they can usually arrange it so as to avoid shadows in passing cranes. In problems such as we have in a large shipping yard of 26 acres operating double turn, makes a big spread and is a place we want well lighted. We have trouble due to vibration from cranes and crane runways and we have been trying to rig up spring suspensions, and are now hanging lamps on Thompson hangers.

A. J. Thompson*: As you will have gathered from Mr. Harrison's paper and what Mr. Blakeslee has said, it is easy to understand that good light, properly placed and maintained, is the least expensive and the most efficient means known for facilitating production and promoting safety—which, by the way, are the only two reasons for having industrial illumination at all. And we may put them in that order advisedly, knowing what we do about human nature. Production comes first, of course—but safety is coming along as a very strong and fast second.

The manufacturers of lighting equipment have spared no effort and no expense to turn out the best equipment that man knows how to make—but its value to the user will depend upon what he does with it, and how he takes care of it. Aside from perhaps protecting the eye from a little glare, there is just one reason for buying a reflector at all for an overhead lamp; that of course is the expectation of saving just about one half of the light which we know is being produced by the bulb, about half of which is projected upward, and half downward—a law of nature. A clean reflector will gather in pretty nearly all of those upward rays of light and bend them down into the working area. A dirty reflector will not save any of those upward rays. No one has ever yet found any kind of dirt that will reflect light.

It seems apparent that many people do not realize that a ray of light is very different from a blast of air or a stream of water, which will be deflected from their course by striking any kind of a barrier. A ray of light, to be bent out of its course, must strike something that has a luster or sparkle. If the luster or sparkle is covered over with a layer of dirt, then the ray of light does not come in contact with the reflecting element, and thereupon becomes lost. The luster or sparkle may be produced by a clean, glossy surface or it may come from exposed crystals. It will not matter how small the crystals are, as in the case of lime crystals in whitewash—each one will gather up such rays of light as come in contact with it, and bend them into another direction exactly in accordance with the laws of nature governing the refraction of light. Of course, as before stated, if the crystals are covered up with dirt the rays of light do not come in contact with them. It is true that some rays of light may slip in between particles of dirt and so be reflected. It follows then that the power of the reflector will depend upon the intensity of its sparkle or luster and its freedom from dirt—for that is what governs its ability to bend the rays of light and deliver them in the desired direction. The only thing about a reflector that is of any value is its reflecting properties. The form and substance of the reflector constitute merely something upon which to hang those reflecting properties—if we may express the idea in that manner. It would be about as logical, or as absurd, to design an automobile without making adequate provision for getting at the gasoline tank for refilling, as to buy high grade reflectors and install them in such a manner as to make them inaccessible for restoring their reflecting properties after they have deteriorated due to dirt.

In the picture which was shown here on the screen, we saw the little chap run along from one lamp to another, reach up and wipe off the bulb. What I wanted to know was what he was going to do about the reflector. Putting a perfectly clean bulb into a dirty reflector will not accomplish anything, or not much! But nobody is every going to thoroughly wash and polish a reflector without wiping off the bulb—so it follows naturally that we can pretty nearly forget the bulb, for it is going to be taken care of as a matter of course if we will only see to it that the reflector is kept in proper condition. The value of the bulb will depend largely upon the condition of the reflector.

The greatest problem in reflector-cleaning is accessibility. Lamps of course will be worthless unless they are installed where they will throw the light down into the working area; but it is difficult to understand why people will pay what they have to pay for as good a piece of apparatus as the modern reflector is, and then put it up where nobody

†Elec. Supt., Bethlehem Steel Co., Bethlehem, Pa.

*Pres., The Thompson Electric Co., Cleveland, Ohio.

can or will get at it to keep it in a reflecting condition.

When lamps have to be installed where it will be difficult or dangerous to get at them for proper and thorough cleaning it is only reasonable that they should be put on a lowering switch or cut-out hanger, so that the work can be done down on the ground in a position of safety, and where the man can hold the reflector under his arm so he can get a purchase on his work, and have a chance to do a thorough job—instead of being obliged to climb up somewhere and then reach up or out at arm's length where he simply cannot get hold of the reflector to hold it as he must do to remove that heavy, sticky dirt.

There is a great deal of difference between wiping out a reflector and giving it a thorough washing and polishing—though the more frequently the cleaning is done the easier it will be to remove the dirt.

It often happens that lamps are put on the end of a long, frail bracket or in a harp on top of a pole where it is impossible for anybody to get hold of the reflector so as to clean it. He might reach out or up and replace a dead bulb, but never would be able to clean the reflector. Then the question arises why the expense of buying a reflector for that lamp, except to serve as a sort of umbrella over the bulb —and as a rule that kind of a job has been laid out by some engineer.

On the subject of shock obsorbers—something over a year ago a suggestion came from a number of steel plants that they would like to have some sort of provision made in connection with our hangers for protecting the lamps from excessive vibration. I thereupon began the development of a shock absorber, which is attracting a good deal of interest. It is exceedingly simple in design, consisting of but three small castings and a spring. There are no screws or bolts in its entire construction. It may be used either with or without the Thompson Hanger. I presume many of you have already seen it, but to any others who may be interested in the subject of a vibration arrester, I would suggest that you examine the samples in my booth at this Iron and Steel Exposition.

Mr. Burr has spoken about installing lamps on a messenger wire—and I want to say that I regard a messenger wire as an ideal shock absorber, because of the resilience interposed between the source of the vibration and the filament of the lamp. However, where hangers are used on a messenger wire, especially if it is a long span with a good deal of sag, I would recommend the use of the catenary construction, so that the hanger will be in a vertical position, and so that the chain or rope can go out in a horizontal direction instead of up at an angle.

H. L. Johnston*: Mr. Harrison's remarks have shown that the use of higher intensities for lighting had been quite general in the past few years. It is surprising to note that foot candle intensities have seldom exceeded from 10 to 20. I recently had occasion to hear a discussion on "Window Fenestration for Factory Buildings" in which lighting intensities in the order of 100 were considered desirable.

It is interesting to note that in the automobile industry there is a general tendency toward daylight intensities in the working area.

*Duquesne Light Company, Pittsburgh, Pa.

One of the recent speakers mentioned the use of larger lamps in the industry. An installation using 1000 watt bare lamps recently came to my attention in a local mill.

I wish to point out that proper attention must be given to the installation of lighting equipment, that the application may be suitable for the location and factory under consideration.

J. S. O'Donovan*: We have given the light question considerable thought for many years. In the old days we used the old type of arc lamp, such as Cooper-Hewitt, Mercury Vapor, and the thing has progressed to where it came to the Mazda lamp. We at our plant took into consideration the cost of the different voltages of lamps, also efficiencies, breakage, etc., and I do not know what the general trend of things in the steel industry is regarding voltages of each individual lamp, but I have found from experience that the low voltage 115 to 120 volt lamp is best. I use 3-wire system for light, 250 and 125 volts. That doesn't need to be carried back to the power house. Check your voltage at lamps occasionally.

Mr. Thompson talked of cleaning the reflectors. I find that the tendency to neglect reflectors is one of the hardest things to overcome. I believe it costs us more money for attention to mazda lamps in care and cleaning than it did in the old type arc lamp, and I believe we are using about ten times the energy per square foot of area than we did ten years ago, and I think that the energy and money required is very well spent.

A. J. Standing: Did you rewire the plant completely, or were you originally 110 to 115 volts? Did you change from high to low voltage?

J. S. O'Donovan: Plant rewired completely and we use direct current for lighting. All motor generator sets are flat voltage compounding. If you want to light with direct current and have 250 volts put in a special system. That is, a balancer set placed across the 250 volt lines. This will give you a 3 wire 250-125 volt system which will pay for itself in a very short while.

F. H. Kittredge†: The average steel mill man has to go beyond the scientific principles of lighting, due to the fact that safety oftentimes demands this condition. For this reason, it is better to have a little more light at certain locations rather than to have too little less light, as an accident would pay for considerable more than the necessary lights, according to scientific rulings. No doubt some of our departments would show up an excess of illumination according to scientific tests and I believe at that we are following out the proper tendency to cater to the safety movement. I also believe that the general tendency at large is to over indulge our eyes along the lines of illumination. An example of this is seen in the ordinary residence as well as in industrial plants by the steadily increasing of the wattage of the units used. In my own home I started out with 40 watt lamps, which seemed satisfactory until I visited some one else's home in which 75 watt units were used. This brought about the change in my own home from 40 to 75 watts with the idea that I was getting better light than I origi-

*Chief Elect., Spang, Chalfant & Co., Etna, Pa.

†Elect. Engineer, Illinois Steel Co., Joliet, Ill.

nally had. The probabilities are that I made this change because the other fellow had rather the actual beneficial conditions to the eyes or better illumination. I think a good ruling to follow is to illuminate according to scientific principles and then elaborate as the necessities call for.

A. J. Standing: Mention has been made two or three times about visiting plants at night time. The appearance of the plant at night is different. Even standard routes look different to those of us who visit the plant periodically at night; but men working week about take their regular routine at night under conditions just as strange to them as it appears to us on our visit. We ought to be particularly careful to give them adequate light.

In our effort to provide sufficient light, we must avoid glare and intense reflection effects which are harmful to the eyes and actually introduce a hazard which offsets the real value of the lighting we are trying to obtain.

P. R. Holmes*: An inspection of the Table of Recommended Foot Candle Values, found in the Appendix to Mr. Harrison's paper reveals the fact that illumination levels of the same order as those recommended for various grades of machine shop work have been specified for many of the operations carried on in the high bay buildings. It is reasonable to expect therefore that like wattage provision be made. Certainly it is not uncommon today to find machine shops lighted by 200 and 300 watt lamps located on 10 foot centers, or in other words, provided with from 2 to 3 watts per square foot of floor area. Likewise, it is not uncommon to find the high bay buildings of steel mills lighted with 300 and 500 watt lamps located on 40 foot centers or a provision of from 0.2 to 0.3 of a watt per square foot. Under these conditions we can naturally only expect one-tenth the recommended illumination. Table No. 4 included in this paper, should prove useful to the engineer in obtaining an idea of spacings and lamp sizes to be used in obtaining desirable illumination levels.

There has been mention made of the importance of properly locating lighting equipment. It seems to me, we had two particularly good examples of this feature shown to us during our inspection through the Homestead plant yesterday. Undoubtedly many were entirely unaware of the presence of floodlighting projectors mounted well out of the range of vision and with the beams of light directed on the rolls of the equipment in the rolling mills. These seemed to do an exceptionally fine job, whereas just the reverse might be said of the supplementary equipment used in obtaining the motion pictures in the generator room. This latter item, as we all know, is not a part of the regular equipment in this particular plant. I am merely citing the example to point out how objectionable units of this character will prove unless properly located. One test of good lighting, I believe, is in making one unconscious of the presence of the equipment.

A. J. Thompson: Mr. Burr spoke of installing lamps on messenger wire. Messenger wire is an ideal shock absorber on account of the amount of resilience imposed. Where they use hangers, I would recommend catenary protection, so the lamp will hang plumb and will go out exactly horizontal. No hanger is any good unless you use it.

Edward Coates*: We have always used 220 volt throughout our plant. It was recommended to us that we change over to 110 volts. Our present costs are $1,200 a month for maintenance. Will it pay us to change over to 110 volts? I think myself 220 volts is coming to the front, and I know we cannot make this change-over under $80,000. We re-wired our shipping plant according to code and the cost was $4,500, and that is only a small portion.

D. W. Blakeslee: Mr. Chairman, if I may speak again: A reference was made to a statement in a paper regarding the cracking and pealing off of the backing of the mirrored glass reflectors in flood lighting projectors. I mentioned this in one of my papers which have been published in the Iron and Steel Engineer. I know that such cracking and peeling has occurred and believe it still does obtain in most makes of mirrored glass reflectors, but since writing that, I find that there is one manufacturer who guarantees that the silver backing will not check, crack nor peel, nor become discolored for a period of ten years.

W. H. Byerle†: Ten or twelve years ago we would put up a light and if we could see, deemed it sufficient and thought it foolish to make it any better. However, those times have changed. We use at Sparrows Point about 5,000 lights for general illumination.

In answer to Mr. Coates' question about 125 vs. 220 volt. At Bethlehem we use 220. The voltages vary from 200 to 250, which is very hard on lamps. On our 125 volt a.c. system, you can keep your voltage constant, but, generally speaking, the big problem with lights in steel mills is that we don't take advantage of what we have in keeping our lights clean, reflectors clean, spacing lights properly, and putting right size lamp in right size reflectors. There are other problems that enter into it, but I think they have been covered by Mr. Harrison and some of the other engineers here very ably.

We have under construction at Sparrows Point a big pipe mill, skelp mills, and just finishing the tin mill, and have gone into the problem of illumination very thoroughly. In fact, in our new pipe mill plant, we are getting outside help; men accustomed to that kind of work, to help us with our problem. We found through experience that they need good lighting for various shops in a pipe mill and in some places we will have 20-foot candles and others as low as 5-foot candles; so we are installing along those lines. Our circuits will be divided, so only one light will work in a certain place, which should be more economical and satisfactory all around.

Ward Harrison‡: To answer Mr. Farrington's question, usually you will find that there is not an air tight connection between the reflector and housing and the conduit to which it is connected, so that when a lamp is burned in the so-called dust-tight or air-tight reflector, the air in it expands due to its increased temperature, and it backs up into the conduit. It is possible, of course, that this connection

*National Lamp Works of G. E. Co., Cleveland, O.

*Elec. Supt., Donner Steel Co., Buffalo, N. Y.

†Elec. Dept., Bethlehem Steel Co., Sparrows Point, Md.

‡Director of Illuminating Engineering, National Lamp Works, Cleveland, Ohio.

might be so tight that this escape of air into the conduit and the resultant relief in pressure could not take place, and therefore trouble might occur. In the majority of cases, however, where the glass cracks it is because it gets too hot, and has no chance to expand; this is particularly true in the case of a flat piece of glass, since it is likely to become overheated in the middle and has little chance for expansion. For this reason it is best to use a plate which is slightly dished.

With regard to 110 versus 220 volt lamps, our records show that where a man has changed from 220, his monthly lamp bill falls very substantially, sometimes almost one-half. The point was raised that 110 volt lamps are more likely to be stolen than 220 and in this way the lighting costs in a given plant might rise to a point where they would be very nearly equal to those which would be incurred if 220 volt lamps were used. That argument has some weight in the case of 25, 40, and 50 watt lamps, but it would scarcely apply to the steel mills, since the majority of the light required here is obtained with large size mogul base lamps used in systems high overhead. There are but few people who want to steal mogul base lamps for they haven't sockets to fit them, and they probably don't want that much current in one spot anyway. Again I have computed from records at certain plants that fully 60% of all the lamps they purchased would have to be stolen before burnout in order to make it pay to use 220 volt lamps to avoid theft.

The question regarding rewiring is one which I am afraid each individual will have to answer for himself. On the other hand this should properly be charged to capital account and in most cases will pay for itself in a remarkably short time. This is particularly true in cases where the old wiring was overloaded anyway with a consequent drop in voltage at the sockets resulting in poor efficiency of lighting.

Mr. Miller's question about monthly lamp reports strikes close home. We all have somebody to whom we must submit cost records, and we often hear him say "Can't you cut it somewhat; why is that so much?" You can't blame an executive for saying this often, for if he didn't he would find the costs going up in most departments. In fact, he often criticizes in this way not for the purpose of actually effecting a reduction but rather to get the full reason for the expenditure. Suppose in answer to his question that you get out your lamp bills of ten years ago and go over them with him. It will open his eyes to see how costs have come down.

In conclusion I have just one suggestion to offer to those who are really interested in better lighting. The suggestion is this: When you feel like being a bit extravagant, just take one building, light it up with Mazda lamps in a way that will involve the expenditure of the same number of dollars per month as you spent when you had it lighted in the old unsatisfactory and meager way with enclosed arc lamps, and then go out some night and look it over. Next go to the executive of the plant and say that you want to show it to him; and after he has seen it tell him that you are only spending as much for light in that building as you absolutely had to spend back in 1910 and ask his approval to the extension of the system to other buildings of the plant.

---

*Discussion: Application of Synchronous Motors in Steel Mills**

By MEMBERSHIP

B. R. Shover§: What is the advantage of the so-called super-synchronous motor over spur motor to start up, using an ordinary friction clutch?

H. A. Winne†: Lower over-all maintenance cost on the drive and I believe the first cost is also lower for super-synchronous than for combined; but the main argument is in maintenance and deliveries required.

O. Needham‡: Mr. Winne has covered this subject in a very thorough manner so that there is not much to be added on the application of synchronous motors to main roll drives. I believe it can be said that the wound rotor induction motor has more nearly ideal torque characteristics for starting and driving a mill. This together with its ability to utilize flywheel effect, will continue to make it the most satisfactory and successful type for many mills. However, there are some other considerable advantages which a synchronous motor has in the way of power factor correction and efficiency that make it a desirable motor to use on mills where it can be applied, and there are a number of such mills. Mr. Winne has explained that a synchronous motor has sufficient starting torque and pull in torque to operate many types of mills successfully, and due to the advantages mentioned above, there is no question but that there is going to be more synchronous motors applied in the future than has been done in the past.

The synchronous motor has a large air gap which is also an advantage, but cases of trouble with induction motors on account of the small air gap are very rare. Mr. Winne also pointed out another advantage of synchronous motors on continuous mills, this being the constant delivery speed by virtue of which more accurate cutting by the flying shear is obtained.

In checking up some figures we find that at the beginning of 1925 there were 3500 H.P. of synchronous motors installed on main rolls in this country and two years later, or by the end of 1926 there was

*Presented before Annual Convention, June 13-18, 1927.

§Consulting Engineer, Pittsburgh, Pa.

†Elec. Engr., General Elec. Co., Schenectady, N. Y.

‡Gen. Engr., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

35,000 H.P. of synchronous motors installed, and this present year is showing an even greater percentage increase than that.

The synchronous motor for main roll drives is rapidly gaining favor and is going to be considered seriously on a large number of future installations. It has desirable characteristics and is entirely applicable to mills such as Mr. Winne outlined where the starting and pull in characteristics of the synchronous motor are ample to take care of the mill.

J. R. Rowbottom*: Are they using many of the small horse power synchronous motors, or are they figuring on using many of them in steel mills?

H. A. Winne: In steel mills the synchronous motor of small horsepower has not made very great inroads as yet. Of course mills are using synchronous motors for pump and compressor drives, but the type I spoke of, 200 h.p. and below, I do not think steel mills are taking hold of, because as a rule the small gain in efficiency or small amount of power factor correction does not make these motors appear so attractive to them as to smaller manufacturing plants where 20 to 75 h.p. may constitute a large part of the total load and good power factor may appreciably lower the power cost.

H. V. Putnam†: Mr. Winne has explained in an excellent manner the general characteristic of synchronous motors, their uses and their limitations. By way of discussion I would like to add a few remarks relating particularly to their starting performance.

The synchronous motor is really a combination of an alternating current generator and a squirrel cage induction motor in a single machine. As a result it possesses probably a greater variety of electrical characteristics than any other rotating machine. For instance, it has efficiency, starting torque, pull in torque, pull-out torque, instantaneous pull-out torque, maximum torque as an induction motor, synchronizing torque, starting or inrush kv-a, power factor, exciter capacity and sometimes still others. Most of these characteristics are within the control of the designer and when we designers do not know exactly what the requirements of the driven machine or the mill are, we are forced to use our own judgment and supply those charactertistics which we think best suited. Also it often happens that certain characteristics such as allowable starting kv-a must depend on circumstances peculiar to a particular installation, such as the size or generating station or the regulation of a transmission line.

Usually the exaggeration or emphasizing of one characteristic results in a sacrifice of other characteristics. Or to state it differently the designer can often exaggerate some particular characteristic, which for some reason may be desirable, if at the same time he is allowed to sacrifice on other characteristics. For instance higher starting torque may be had at a sacrifice, of pull in torque. But if both high starting and pull in are necessary then it must be paid for in the form of a higher inrush.

Similarly low inrush can be had if low pull out torque can be permitted and it is much easier to get the low inrush if the motor can be designed for high starting torque and low pull in torque at the same time. But if the machine must have both high pull in and high pull out torque then it must of necessity have high inrush.

From these examples it is clear that you users, or electrical superintendents can help us designers a great deal by telling us as accurately as possible, what your mill requirements are. Don't tell us you must have the highest starting, pull in and pull out torques with the lowest inrush but try to tell us the truth about your requirements as near as possible. We will then be in a position to design intelligently the best and most economical motor for the application. This will do more to bring about the development of new synchronous motor applications than anything else.

The two most popular subjects of discussion in synchronous motor circles today are full voltage starting and damper winding design. I would like to say a word about each. We are being called upon to design motors today for full voltage starting which two years ago we wouldn't have considered. Motors of two or three hundred horse-power at 1800 r.p.m. would ordinarily have an inrush of seven or eight times normal current but we have found that it is possible to design such machines with inrushes from 4 to 4½ times which are usually acceptable for full voltage starting. At least such inrushes will not do the motor any injury and it is simply a matter of providing the necessary starting kv-a. We used to think that there was an economical limit to the size of machine that could be started across the line but that limit if it ever did exist is rapidly disappearing with the newest developments. It was usually supposed that a machine with a pole pitch greater than eight or ten inches would have too high an inrush for full voltage starting. But now we find when we really try it is possible to get enough reactance into such machines, to bring the inrush low enough for full voltage starting.

I would not be so bold as to say that one could design a 9,000 horse power machine like the McKinney Steel motor with an inrush low enough to be suitable for full voltage starting, but it does not require a very great stretch of the imagination to conceive such a possibility. One could easily design a 900 horse-power machine for full voltage starting. Then by making a humble application of Einstein's Theory of Relativity one could imagine all dimensions of the core and slots increased in the ratio of about 2.1 and then a 9,000 horse-power machine would result, having the same percentage starting kv-a and starting torque as the 900.

Full voltage starting is an economically sound development because of the great simplicity in the control and hence greater reliability. It also represents a less total investment because any increase in motor cost is more than offset by the saving in the control.

Guarantees of starting kv-a should be made on the basis locked rotor kv-a. Some manufacturers have been making inrush guarantees on the basis of what is known in induction motor practice as "free rotor kv-a." This is defined as the kv-a indicated by an ammeter when the motor starts up light. In small induction motors this value is about 60 or 75 per cent of the locked rotor kv-a. It does not represent the actual surge on the line. It is not even a characteristic of the motor but rather a characteristic of the ammeter so that it is absurd to make guarantees

*Thomas Sheet Steel Co., Niles, O.

†Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

on this basis. The more highly damped the meter is the lower will be the indication. Carried to its logical conclusion this means that if you throw the meter away or tie the needle to the scale the inrush is zero. In comparing the starting performance of different motors care should be taken to see that all guarantees of inrush are made on the basis of locked rotor kv-a.

Mr. Winne has mentioned that the damper windings of synchronous motors are designed only for starting. As a result they can be designed with high resistance bars which produce high starting torque while in our induction motor this would be impossible because of the high slip, poor power factor and low efficiency which would result. During the starting period an enormous amount of heat is generated in damper winding, far more than can be radiated from the winding. This heat must therefore be stored during the starting period. This can be done most effectively by having the bars in intimate contact with the pole iron for their whole length. The iron of the pole can then carry away the heat from the damper bars, conducting it down into the pole bodies and spider, where there is ample capacity for storing it. But portions of the damper bars which extend beyond the end of the pole have nothing to conduct the heat away and consequently are apt to burn up under severe starting duty. The best damper winding will have no portions of the bars exposed to the air.

There is considerable misunderstanding as to why some motors will carry full load on their damper winding operating as induction motors, and others will not. When a motor operates on the damper winding additional heat is generated in the stator due to the magnetizing current which flows in the stator. Additional heat is also generated in the rotor due to the load current flowing. Usually the rotor heating is the limiting factor. This heating is proportional to the slip at full load. A motor with a low starting torque and high pull in torque will therefore give the best performance operating on the damper winding, since such a machine will have low slip at full load. A machine with 100 or 125 per cent pull in torque is bound to deliver full load on the damper winding without excessive heating in the rotor.

Mr. Winne's curves on the McKinney steel motor show that this motor has less than five per cent slip at 100 per cent torque so that in all probability this motor would carry full load on the damper winding without excessive heating. A slight increase in the load over 100 per cent would, however, produce a large slip and excessive heating in the rotor.

I noticed, however, that Mr. Winne's current curve seems to show 20,000 kv-a input at 5 per cent slip or about three times normal current. I see no reason why this machine should require so much kv-a at this slip and I would like to ask Mr. Winne if he doesn't think there is something wrong with this portion of the curve. If the curve is right this means that the heating in the stator would preclude operating on the damper winding at anywhere near full load for any length of time. Using 1½ per cent stator resistance I find his curves show a power factor at starting of about 46% and at 5% slip, a power factor of only about 40%. This doesn't seem possible, and indicated, I think, some error in the current curve at the pull in point. Usually as a motor comes up to speed the power factor gets better on account of the decreasing rotor reactance due to the decreasing frequency of the rotor current. In synchronous motors this effect is somewhat offset by the fact that as the motor comes up to speed a larger portion of the rotor current flows in the field circuit which inherently has poorer power factor. But I have calculated many cases of motors with high resistance damper winding like the McKinney Steel motor and never before have I seen a case where the power factor was poorer at five per cent slip than at starting.

H. A. Winne: Mr. Needham says that the induction motor is ideal from the rolling mill standpoint. I cannot quite agree with him because if it were ideal we would not be justified in applying synchronous motors. Possibly it is ideal from the standpoint of starting but the synchronous motor has other characteristics which in some circumstances make it preferable to the induction motor. Personally I do not think that the control for the synchronous motor is any more complicated—I mean in the sense that it will cause more trouble or maintenance —than the control for a wound rotor induction motor. The synchronous motor requires a greater number of oil circuit breakers, and an auto transformer, but the induction motor requires secondary contactors, relays, and resistance, so that I believe there is not much to choose between the two.

I want to thank Mr. Putnam for so able amplifying my paper from the standpoint of a designing engineer. Personally I spend my time in the application rather than in the design of motors and so probably am not so well qualified to speak on some of the finer points of design as is Mr. Putman.

Starting a motor at full voltage is advantageous because every time you can throw away a piece of control apparatus I think you further the reliability of the operation of your plant. I don't mean at all that control equipment is not reliable, for it is extremely so, but apparatus of any type is subject to difficulties and a step towards simplification, providing you do not lose some valuable operating feature thereby, is always a step in the right direction. While we never supposed that the 9,000 h.p. synchronous motor at the Corrigan McKinney Steel Company would be started at full voltage, because it would require more kv-a, inrush than the power system could possibly supply, the motor itself is so designed that full voltage starting would be entirely feasible and we would not hesitate to throw it on full voltage providing somebody will supply the necessary kv-a.

Mr. Putman mentioned the inrush kv-a when starting small synchronous motors. As I think I stated previously, the small general purpose synchronous motor has better starting characteristics, that is, a greater starting torque per kv-a inrush, than the corresponding squirrel cage induction motor. The reason is that the squirrel cage starting winding on the synchronous motor can be designed for starting purposes only whereas the squirrel cage winding of the induction motor must be designed primarily to give good running operation with starting as a secondary though important consideration.

As far as the design of the squirrel cage winding is concerned, it is perfectly true that we do not depend on the winding itself to dissipate all the heat

that is generated by the starting cycle. A large proportion of this heat must be taken care of by conduction to the iron of the pole piece which surrounds the squirrel cage rods. Failures of damper or squirrel cage windings do not usually occur in the bars themselves, but rather at the joint between the bar and the end ring. The General Electric Company has done a great deal of research work in perfecting what we believe is the best type of joint for this purpose.

When I stated that with a synchronous motor running without field excitation, an overload protective device which would protect the stator winding would also protect the squirrel cage winding, I meant the modern types of protective devices which take account, not only of load, but of time as well, such as temperature overload relays. If such a device is used and is set so as to protect the stator winding under the conditions mentioned, the damper windings in our standard line of general purpose synchronous motors will not be damaged due to operation without field on the motor so long as the stator current is not sufficient to operate the protective device.

As for the torque and current curves shown in Figure 5, Mr. Putman is correct in stating that these show that full load torque is obtained at slightly less than 5% slip, indicating a fairly low resistance rotor winding. However, I believe that in his comments as regards this fact and the power factor, he has lost sight of the fact that these curves show the starting conditions of the motor with the field closed through a small amount of resistance. This use of the field circuit during starting gives quite different torque and current characteristics than are obtained if the field is open circuited and I believe Mr. Putnam's remarks are based on consideration of the effect of the squirrel cage winding alone and do not take into account this field circuit. Suffice it to say that these curves are based on the results of tests and I feel certain that they are correct.

W. H. Feldmann*: It was fortunate that Mr. Winne's paper was placed on the program after the ones we heard this morning on anti-friction bearings. Due to the elimination of static friction synchronous motors will be suitable for many more steel mill drives than at present because of the reduction in starting torque requirements. A good illustration of the severity of starting torque requirements caused by static friction of a great number of bearings is a flour mill. Often a torque of 200 to 300 per cent of normal is required to break the various line shafts from rest. This is easily understood in consideration of the statement made by one of the men in this morning's discussion that a sleeve bearing required about 100 times as much power to overcome friction when at standstill than when running under normal conditions.

Our company made an application of a synchronous motor driving a tube rolling mill in a steamless tube mill several years ago. Due to the use of sleeve bearings it was necessary to provide the motor with exceptionally high starting torque to break the mill from rest due, of course, to the fact that there was no film of oil between the shafts and bearings. In considering a similar installation a few months ago it was determined, because the mill was equipped with anti-friction bearings, that because of the marked reduction in starting requirements a smaller sized motor could be used from the standpoint of starting torque requirements.

Mention has been made of the compensator and Korndorffer methods of motor starting. I would like to call attention also to the so-called reactor scheme of starting, which is suitable in some cases.

This method requires a reactance external to the motor, a running switch and reactor short-circuiting switch. The reactor is in series with the motor during the starting period and limits the motor current to the amount required to start it. When the motor reaches synchronism, the drop across the reactor is very small—corresponding to the running light current of the motor—and the reactor is then short-circuited.

Compared with the other methods of starting, the advantage of the reactor method lies in the simplicity of equipment and operation; its application depends on the amount kv-a which can be taken at starting, without disturbing unduly the voltage of the system.

E. G. Merrick*: An investigation of the conditions in many industrial plants reveals a situation which is so inimical to safety that I believe it deserves more consideration than it apparently receives.

In generating stations, or main sub-stations, adequate switching equipment is generally provided; these installations are made, as a rule, in accordance with engineering recommendations and the type of apparatus used is suitable for the normal and transient duties to which it may be sujected.

Feeders are carried from the generating or substations to the points where power is used and it is frequently found that the equipment at these points has been selected without reference to the duty to be performed—particularly as regards short-circuits.

Motors with control equipment are generally purchased on a supply basis and this control, while perfectly safe in some locations, may be entirely inadequate in other installations where the short circuit duty is severe.

In order to avoid the many accidents to operators resulting from the situation mentioned, it would appear advisable to limit the amount of short circuit current which can be developed at load points to moderate values which can be safely handled by the average class of control equipment used in mills, etc. This limitation of current can usually be realized satisfactorily by means of feeder reactors.

Having limited the short-circuit currents to definite predetermined values, care should be taken to select control equipment suitable for the duty prescribed.

H. V. Putman: With reactor starting, a larger kv-a is required than is the case with an auto-transformer. If a motor takes 1,000 kv-a at full voltage and it is started on 50% voltage with an auto-transformer, the kv-a taken from the line is 250 or 25% of the full voltage value. If it is started on 50% voltage with reactors the kv-a is 500 or 50% of the full voltage value. This is a point to remember in making an application of reactor starting.

H. A. Winne: The point is very well taken and it is because of the fact that with reactor starting a greater kv-a input is required for a given torque that

*Electric Machinery Mfg. Co., Minneapolis, Minn.

*General Electric Co., Schenectady, N. Y.

I don't look to see very many applications of this type of starting to main roll drive motors, especially of large capacity. However, for motors used as part of motor generator sets and others where the starting duty is comparatively light, the reactor method of starting is considerably simpler and I believe safer than the use of an auto transformer. Also, I think that starting reactors, particularly of the air core type, will give less trouble than starting auto transformers.

K. A. Nygren*: It took us three years to get designers to put a synchronous motor in a rolling mill. They were not interested; said it could not be done; but after about three years we got them to agree that there should be a synchronous motor. We have had it now for 2½ years and we are very well pleased with it. You could not sell slip ring motors to us at all. Formerly power-factor 65; now we run 95. We can run leading power factor which is an advantage to us.

O. Needham: The use of a synchronous motor to drive a cold sheet mill has been mentioned. The load on such a mill after the motor is up to speed is fairly constant and perfectly suitable for using a synchronous motor. These mills require a high starting torque and where line voltage starting is permissible it is possible to apply a synchronous motor which will have sufficient starting torque to operate a mill of this kind. Such an application is now being made.

A. J. Standing: I do not know whether the question has been asked or answered, as to what extent would it be permissible to take old synchronous motors, 6600 volts and 300 or 400 h.p. and revamp the starting equipment to avoid compensating starting. What are the characteristics of the standard motors within the past 8 or 10 years due to the recent change in the art?

H. A. Winne: As for reactor starting, it is entirely feasible and many times very desirable to use a series reactor during the starting period rather than an auto transformer. The reactor must be designed with a full knowledge of the characteristics of the motor, and so proportioned that when the motor at standstill is connected in series with the reactor to the line, the current drawn will entail a voltage drop through the reactor which will result in approximately the same voltage at the motor terminals as though an auto transformer had been used to obtain the reduced voltage. The reactor offers the advantage of eliminating one oil switch, and the transfer from the starting condition to running conditions is made more easily and with less disturbance than with an auto transformer. However, the starting kv-a will be greater with the reactor than with the auto transformer because with the reactor you lose the advantage of the transforming ratio of the auto transformer. In other words, for a given motor current, if a reactor is used the line current will be the same as the motor current, whereas if an auto transformer is used, the line current will be less than the motor current due to the transformer ratio.

As to Mr. Standing's question regarding starting an old synchronous motor by throwing it directly on the line, whether this is safe practice will depend on the design of the individual motor in question. On motors designed for full voltage starting it is the present-day practice to very securely brace the end turns of the coils, and it is questionable whether a motor as old as the one in consideration would have this brace. The safest thing to do would be to take the question up with the manufacturer of the motor.

H. V. Putman: Often motor manufacturers will say that it is impossible to change over a motor originally designed for reduced voltage starting, to full voltage starting because the motor is not good enough to stand the higher inrush. We find some motors stand surprisingly high inrush without injury. It is safe to say that any standard motor can be sufficiently well braced to stand an inrush of four and one-half or five times normal current. Some machines are in operation starting at full voltage with 600% inrush and apparently without injury. In changing over a motor from reduced voltage to full voltage starting, about the only thing the user can do is to see to it that the motor is braced in the best possible manner and, if the inrush is not more than five times normal kv-a when started at full voltage, the application will, in all probability, be successful.

Most of the new machines which will be designed for full voltage starting will have fewer slots, fewer armature coils, and fewer bars per pole, in order to get higher reactance in both rotor and stator.

J. D. Rowbotham: Answering the question in regard to starting across the line I would advise the gentleman to take a chance. In one instance recently I was in a position where it was necessary, on account of a burned out compensator, to start a 150 K.W. M. G. set across the line. This I did, 15 or 20 times without damage to the machine which is 12 years old.

*General Supt., Globe Steel Tubes Co., Milwaukee, Wis.

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

IRON AND STEEL ENGINEER

(Required by Act of Congress of August 24, 1912)

Name of Publication: Iron and Steel Engineer, published monthly at Pittsburgh, Pa. (Report of October 1, 1927)

Editor—John F. Kelly, Empire Bldg., Pittsburgh, Pa.

Business Manager—John F. Kelly, Empire Bldg., Pittsburgh, Pa.

Names and addresses of stockholders holding 1 per cent or more of total amount of stock: None.

Board of Directors

S. S. Wales, President, Carnegie Steel Company, Pittsburgh, Pa.
A. J. Standing, First Vice President, Bethlehem Steel Corp., Saucon Plant, Bethlehem, Pa.
C. S. Proudfoot, Second Vice President, United States Ferro Alloys Corp., Niagara Falls, N. Y.
George H. Schaeffer, Past Pres., The Carpenter Steel Co., Reading, Pa.
A. C. Cummins, Past President, Carnegie Steel Co., Duquesne, Pa.
James Farrington, Treasurer, Wheeling Steel Corp., Steubenville, O.
F. W. Cramer, Secretary, Bethlehem Steel Corp., Johnstown, Pa.
R. S. Shoemaker, Director, American Rolling Mills Co., Middletown, O.
F. L. Collins, Director, Illinois Steel Co., Gary, Ind.
H. C. Seibert, Director, Bethlehem Steel Corp., Bethlehem, Pa.
C. L. Baker, Director, Bethlehem Steel Corp., Johnstown, Pa.
A. G. Place, Director, Youngstown Sheet and Tube Co., Youngstown, O.
E. Friedlander, Honorary Director, Pittsburgh, Pa.

Known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities: None.

JOHN R. DOYLE, Asst. Editor.

Sworn to and subscribed before me this 20th day of September, 1927.

LEAH H. RUGG, Notary Public.

(My commission expires January 20th, 1930.)

*Electrical Installations at Aliquippa Plant of the Jones & Laughlin Steel Corporation**

By R. W. HUSSEY†

YOU visited, this afternoon, the Aliquippa Works of the Jones & Laughlin Steel Corporation at Woodlawn, Pa. Starting at the South end of the plant, you were escorted through the Powdered Coal Boiler Plant, the South Power House, past the Tin Plate, Rod and Wire Departments, to the 30" Round Mill, through the 30" Round Mill and Seamless Tube Plant, thence by train to the By-Product Coke Plant, back to the 14" Mill, 10" Skelp Mill, Billet, Bar and Blooming Mills, through the Open Hearth and Bessemer Departments, then to the Blowing Engine Room, through the North Power House and Switch Tower to the Blast Furnace Department.

The following is a brief description of the plant which you visited:

The Powdered Coal Boiler Plant comprises five boilers, each rated at nearly 2,000 HP., 100 per cent rating, two pulverizers and one fan per boiler, together with necessary pumps and coal handling equipment. The greater part of electric power for the auxiliaries in this plant is furnished by a small turbo-generator in the South Power House. This turbine operates non-condensing and supplies exhaust steam heating to feed water heaters.

In the South Power House, there are one 17,000, two 10,000, and one 750 KW. turbo-generators, feed water heaters and pumps for the boiler plant and switching equipment for all outgoing circuits. The 6,600 volt bus is sectionalized in this station, the 17,000 KW. turbo-generator and several out-going circuits being on one section, Section A, the two (2) 10,000 KW. turbo-generators on Section B, and the 750 KW. turbo-generator is on Section C bus carrying part of the boiler plant load. All three sections may be operated as one bus, reactors and a switch being provided so that sections A and B may be operated either with reactors between them or with the reactors shunted.

A description of the 6,600 volt power system at this time should help in giving you a better understanding of the plant layout and operation.

The South Power House turbo-generators, described above, with a combined rating of 45,900 K.V.A., and two 5,550 K.V.A. turbo-generators in the North Power House, a grand total of 57,000 K.V.A., generates all of the 6,600-volt, 25-cycle power used at the Aliquippa Plant. A comparatively small amount of 250-volt D.C. power is generated in the North Power House by reciprocating engine-driven generators, and several hundred thousand K.W. Hrs. of 60-cycle power per month are purchased for one rolling mill.

Two 600,000 cm and two 4/0 bare copper circuits connect the two power plants. The 600,000 cm circuits are used as trunk lines between the two places, no taps being taken from them. The 4/0 circuits are tapped at various places to feed certain sub-stations, but pole top switches are so arranged that these two circuits may be used either as radial feeders or as trunk lines. All other 6,600-volt circuits to various motor rooms, and to the majority of sub-stations, are radial feeders, emanating from either the South or North Power House.

The 6,600-volt equipment in the North Power House is not of recent design and is protected against the more powerful South Mills Station by a switch tower with modern high rupturing capacity switches, installed in vertical, isolated phase arrangement and a set of reactors in the tie lines between the switch tower bus and the North Power House bus. This switch tower also contains radial feeder switches for the bulk of power used in the rolling mills, a pumping station and the By-Product Plant.

Nine sub-stations, together with M-G sets and transformers at North Power House, and a transformer bank at South Power House, convert or transform 6,600-volt, 25-cycle power to low voltage power for auxiliary equipment. Three rolling mills and a pumping plant use 6,600-volt, 25-cycle power direct over radial feeders.

The 30" Round Mill, recently installed as a feeder for the new Seamless Tube Plant, is motor driven. The motor room houses the 3,000 HP. reversing motor, the 3,200 K.W. M-G set, incoming line switches, M-G set and transformer switches, and other auxiliary electrical equipment. The 3,000 HP. reversing motor is kept cool and clean by forced ventilation, air being drawn through dry-type air filters and blown through the motor. Air of the same kind and pressure is also delivered to the M-G set pit. Forced ventilation creates a positive pressure in the motor room, preventing any infiltration of dust and it is expected that the electrical equipment will always be kept in the best of condition with least amount of expense. A gas producing plant, two (2) gas-fired billet furnaces, motor driven pushers, ejectors, tables and manipulators, a motor driven hot-saw, three overhead electric cranes and the 30" rolling mill make up the Round Mill installation.

The Seamless Tube Plant comprises a gas producing plant, furnace building, hot mill building, straightening building, cut off, threading and shipping buildings. There are 11 traveling cranes overhead.

A sub-station, in the south end of the straightening building, contains two (2) automatically controlled, 1,000 K.W. M-G sets, eight (8) automatically reclosing breaker D.C. feeder panels, a 230-volt A.C. switchboard, two (2) incoming 6,600-volt line circuit-breakers and a truck-type switchboard for the control of M-G sets, air compressors, 1,500 K.V.A. transformer bank, and main drive 6,600-volt motors

*Presented at the September 22, 1927, meeting of the Pittsburgh Section, A. I. & S. E. E.

†Elec. Supt., Jones & Laughlin Steel Corp., Woodlawn, Pa.

in the Hot Mill. A central forced ventilation system supplies filtered air through underground ducts to all main drive motors, the sub-station and air compressor motors.

Several hundred ball bearing general purpose motors and roller-bearing mill type motors recently designed to conform to the A. I. & S. E. E. standards for mill type motors, drive the threading, cut-off and boring machines, tables, pushers and overhead cranes and other auxiliaries.

Among the fourteen (14) overhead electric cranes in the Round Mill and Seamless Tube Plant, two (2) are fitted with roller bearings throughout, except in the motor back-axle bearings, and a third crane is equipped with roller bearings on the bridge drive, except in the motor back-axle bearings.

Observations recently made on the operation of two (2) cranes on the same runway, one crane equipped throughout with plain sleeve bearings and the other with roller bearings, gave us the following data:

The sleeve bearing crane bridge is driven by two (2) 65 HP. motors at the rate of 700 feet per minute, and the roller bearing crane bridge is driven by two (2) 33 HP. motors at the rate of 740/750 feet per minute. It is estimated that the difference in cost between the pair of 65 HP. motors and the pair of 33 HP. motors will more than pay for the roller bearings on the bridge drive, including the line shaft and idlers.

Although only three cranes have roller bearings in addition to those in the motors, all crane bridges are so designed that roller bearings may be installed later and those roller bearing housings already in use are interchangeable with the M.C.B. bearings on other cranes.

Both Round Mill and Seamless Tube Plant are supplied with 6,600-volt 25-cycle power over two (2) 1,000,000 cm radial feeder circuits from the South Power House. The line switching equipment at the sub-station ends of these two circuits are so arranged that the Seamless Tube Plant may use either circuit, the Round Mill either circuit or both places on the same circuit, and both circuits may be paralleled in either sub-station.

The Welded Tube Department sections are four (4) butt weld mills, three (3) lap weld mills, a coupling shop and a galvanizing department. The welding rolls, draw benches, chargers, threading machinery, overhead cranes, and other auxiliary machinery are all driven by low voltage motors. A sub-station for this department contains two (2) 1,000 KW. M-G sets and a 1,500 K.V.A. bank of transformers, while another 1,500 K.V.A. bank is installed remote from the sub-station.

The electrical installation at the By-Product Coke Plant is the sub-station which supplies 230 volts D.C. and 230 volts A.C. to the car dumper, various larries, pushers and valve gears, conveyors, crushers, pumps, etc., and also controls the 6,600-volt power used in the two hammer mill motors.

This station is fed by two radial feeders from the North Power House. Two (2) incoming line circuit breakers protect the station and the truck-type switchboard. Two (2) 300 KW. M-G sets, one (1) 150 K.V.A. and one (1) 2,250 K.V.A. transformer banks supply the lower voltage power.

The low voltage feed lines, running out of this station, are all of the lead covered cable type, installed in ducts laid underground in concrete.

The 14" Rolling Mill is our one (1) 60-cycle installation. The power, purchased for this mill comes to us over two (2) 22,000-volt circuits, is switched and metered in a switch house outside of the mill building and is then stepped down to 6,600 volts in a 12,000 K.V.A. transformer bank. The 6,600-volt, 60-cycle power, is transmitted to the motor room over three (3) three-conductor, lead-covered cables to a short bus under the motor room floor. Taps rise from this bus to two (2) high rupturing capacity breakers and from these two switches, cables run to the two (2) sections of the truck-type switchboard. One section of this truck-type switchboard controls the power used in the M-G sets within the motor room, and the other section, the power used in a small bank of power transformers, an air compressor and two (2) centrifugal pump motors.

The main drive machines in this mill are all 600-volt D.C. adjustable speed motors. One 5,000 KW. M-G set and two (2) 3,600 KW. sets furnish 600-volt D.C. power for the main drives. A 300 KW. M-G set is used as a stand-by exciter set for the room, a 1,000 KW. M-G set supplies the auxiliary motors, and an adjustable frequency 350 K.V.A. M-G set furnishes power for the hot-run-out roller motors.

The M-G sets are started by the motor room attendant, but the main drive motors are controlled entirely by an operator in a pulpit on the opposite side of the mill. The control pulpit is connected with the motor room by an underground passageway through which are run, exposed, all control cable conduit.

Two (2) 100 HP. motor-driven fans, each of 100,000 c.f.m. capacity against 4" static pressure, furnish air, taken through 200 units of air-filtering equipment, for all main drive motors, air compressor motor and the compressor intake, and also keeps the tunnel and pulpit basement ventilated. A good pressure is maintained in the motor room and the room has been kept remarkably free of outside dirt. Since putting this ventilating system in operation in January, 1924, it has not been deemed necessary to clean any part of the electrical equipment inside the motor room.

The 10" mill, a continuous mill for skelp and flats, is driven by two (2) 2,000 HP. 6,600-volt induction motors and a 167 HP. 440-volt motor on a vertical edging mill. The various main drive motors are provided with Scherbius control equipment for 25 per cent speed regulation below synchronism. Power for this mill comes over two (2) radial feeders, one from the North Switch Tower, and the other from the North Power House bus. The same typical construction obtains at this point; two (2) incoming high rupturing capacity line circuit-breakers and a sectionalized bus with switching equipment in concrete cells.

The Billet and Bar Mills, two separate mills, each having an 18 inch train and a 21 inch train, are driven by four (4) 5750 HP. motors, one on each train. Sixty-six-hundred-volt, 25-cycle, power for these four motors is transmitted over three (3) radial feeders, two (2) from the North Switch Tower for normal operations, and a stand-by circuit from the

North Power House that is common to both Bar and Billet Mill switch rooms. These motors are operated by rollers at the various mills. Mechanical arrangements are made so that either motor on the Billet Mill can drive the entire mill and, likewise for the Bar Mill.

The Blooming Mill electrical installation is all low voltage equipment for crane and auxiliary motors. Soaking Pit, cranes, pit covers, tables, fans, a motor-driven bloom shear, and haulage make up the list of machinery that is motor-driven.

The Open Hearth Department has four (4) Talbot furnaces with motor operated tilting mechanisms, three (3) 150-ton ladle cranes, three (3) hot metal cranes, three (3) charging machines, repair cranes, stock cranes, and two (2) 150-ton strippers. Each furnace is tilted by four (4) 50 HP., half-hour rated, mill type motors, two (2) motor-driven gears, and a screw on each of two rockers. The south motors on each gear train are connected in series and the north motors are hooked up the same way. One pair of motors may be cut out at the control board and the furnace may still be operated. In case of magnetic control troubles, emergency switches may be so manipulated that all motors are connected directly to the power lines with a certain amount of line resistance in series, and the furnaces returned to an upright position. Dead-man masters operate two line contactors in each control house and are separate from the switchboards which are controlled by other master switches.

The Bessemer division of the Open Hearth Department contains three (3) 25-ton converters, a 400-ton and one (1) 600-ton mixers, and a pouring platform. One of the converters and the 600-ton mixer are motor driven, other vessels, and the 400-ton mixer, being hydraulically operated. There are two (2) overhead cranes in the converter building and two (2) in the pouring building. Two (2) cranes in the slag dock and a gantry crane at the skull yard are also a part of the Open Hearth and Bessemer Department equipment.

The Blowing Engine Room and North Power House adjoin and line up parallel to, but between, the Blooming Mill Department and Blast Furnace Departments. A boiler plant, using Blast Furnace gas, occupies space between the North Power House, Blowing Engine buildings and the Blast Furnaces.

There are two (2) turbine-driven centrifugal compressors and ten (10) reciprocating engine type blowers in the Blowing Engine Room. The centrifugal compressors are of 36,500/45,000 c.f.m. capacity, with a turbine rating of 4,590/5770 H.P. at 3830/4050 R.P.M. One compressor supplies air for the Bessemer converters and the other compressor with the ten (10) blowing engines supplies the Blast Furnaces.

The North Power House equipment has already been described in part. It consists of two (2) 1,000 KW. reciprocating engine drivers, 250-volt D.C. generators, two (2) 1,000 KW. A.C. units with same kind of engines, two (2) 1,000 KW. M-G sets, two (2) 5,550 K.V.A. turbo-generators, one motor-driven and two steam-driven air compressors, a 6,600-volt, double bus, switching and metering panels. All D.C. and 230-volt A.C. power used in the North Mills, except at the Sintering Plant and some D.C. power used in the ore yards, is distributed through this Power House. Sixty-six-hundred-volt circuits go out of this station as radial type feeders to the Sintering Plant, By-Product Coke Plant, Central Pumping Station, Billet, Bar and 10″ Skelp Mills, but these circuits, with the older and lower rupturing capacity switching equipment, are used as stand-by circuits. The bulk of power to these places is transmitted over radial type feeders from the North Switch Tower, just outside the south end of the North Power House.

The Switch Tower contains seven (7) 2,000 Amp. 15,000-volt oil circuit breakers of isolated phase type arranged vertically. Two (2) of these are used as trunk line switches and five (5) as feeders. The three lowest floors are switch rooms, the fourth floor a mechanism room and the uppermost floor houses the line disconnectors and also has space set aside for the switchboard and meter panels which are now temporarily installed in the North Power House. Choke coils, lightning arrester and lightning arrester disconnects, are mounted on the roof.

The Blast Furnace Department comprises five (5) furnaces and stock houses, a boiler plant, ladle and pig casting house, Sintering Plant and ore yard with two (2) bridges and one car dumper. All furnaces are charged by double bucket skip hoists, D.C. motor driven. There are motor driven distributors at the top of two (2) furnaces.

During relining work two furnaces were enlarged. In order to handle a greater tonnage of raw materials the two skips were speeded-up, one by means of a gear change and the installation of new control, the other by new control only. The increase in speed of the skip recently speeded-up was accomplished by installing a new controller to accelerate the motor with full shunt and series field, then cutting out the series field and lastly, weakening the shunt field. A trip of over 12,000 pounds of ore is now made in less than 38 seconds, and the full load running speed is 430 feet per minute.

The ore bridge, transfer car, car dumper, electric locomotive and stock house larry car equipment is all supplied with electric power over double conductor bars, no grounded system being used.

The Coal Handling and Rectangular Coke Oven Departments at the South Mills, the Tin Plate and Rod and Wire Departments, which were not inspected in detail on account of available time spent in other departments of the plant, contain the usual electrical installations.

Coal hoists, car haulages, screens, pumps, pushers, and larry cars at the Coal Handling and Rectangular Oven Departments, are supplied with 250-volt D.C. and 230-volt A.C. power from a sub-station centrally located with respect to the two departments.

The Tin Plate Department is electrically equipped on squaring and doubling shears, hydraulic pumps, at the Dressler Furnace, and other annealing furnaces, on tinning and cleaning machines and on overhead cranes.

Overhead cranes in the Billet Yard and in the Rod Mill proper, pumps in the Rod Mill Engine room, conveyors, wire benches, nail mill line shafts, the various fence machines and the Junior Beam Fabricating Department, which is located at the extreme north end of the Rod and Wire Department, are completely equipped with motors.

The Tin Plate and Rod and Wire Departments are supplied both 250-volt D.C. and 230-volt A.C.

power through the Rod Mill and Nail Mill sub-stations. The Rod Mill sub-station contains three (3) 500 KW. rotary converters, and a 3,000 KW. transformer bank, and the Nail Mill sub-station a 1,500 K.V.A. transformer bank.

All sub-stations and switch houses wherein are installed 6,600-volt switching, are equipped with storage batteries for stand-by control power, except at the Rod Mill and Nail Mill sub-stations, which will be so equipped during future improvement work.

In closing, it might be of interest to know about a few other things applying to the plant in general.

All out-doors insulators and cable terminals on the 6,600-volt system are of the 25,000-volt class, or higher.

All disconnecting switches on the 6,600-volt lines are interlocked by some key-operated device with the circuit breakers in such a way that the disconnects cannot be opened under load.

Nearly all 6,600-volt power is distributed to the various sub-stations and motor rooms over two feeders of the radial type, so called, to each place, choke coils and lightning arresters being mounted outside and incoming line circuitbreakers inside. Although the two circuits to each place may be paralleled through the circuit breakers inside, this is never done, except to change over from one circuit to the other.

During the last two or three years, many roller and ball bearing motors have been installed and many of the older motors have been equipped with anti-friction bearings, all of which have proven very satisfactory in operation and have helped materially in keeping repairs at a minimum.

DISCUSSION

A. C. Cummins†: Mr. Hussey's paper together with the inspection trip, gives everyone a most comprehensive view of the operation of one of America's most modern steel plants. There are several points in Mr. Hussey's paper which arouses much interest, and about which I would like to ask a few questions.

Mr. Hussey spoke of the way in which the location of the lightning arresters had been changed from the interior of his power house to the exterior and that very little trouble had been experienced with lightning since this change. In the upper section of the valley there have been fewer electrical storms during the past two years than previously experienced, and I am wondering if this has not been the case at Woodlawn, and if it has not had as much to do with the improved conditions as changing the location of the arresters.

Another question is whether the 6600 volt system at Woodlawn is operated with the neutral grounded? Some of our large steel plants have made the necessary connections to ground the neutral of their 6600 volt systems and are reporting fewer failures of equipment since the installation of a ground has been made. If Mr. Hussey's neutral is grounded, does the improvement in service justify the expense of installation.

In the latter part of Mr. Hussey's paper a reference was made to the installation of roller bearings on motors of the older types installed in steel mills about 20 years ago. We have made over 100 similar applications of roller bearings at Duquesne, and have encountered some difficulties, particularly when applications were attempted on motors of the so-called "railway type," in which shaft sizes are smaller in proportion to the torques developed than in modern mill type motors. Shaft breakages have been quite a factor and have caused us to hesitate in our program of roller bearing applications until we gather more data based on experience. It is our theory that these shaft breakages are caused by concentration of bending moments at the places in the shafts where diameters change, and also where bearing races are shrunk on the shaft. It would be interesting to hear Mr. Hussey's experiences in this connection or that of any other members who have attempted equipping railway type motors with anti-friction bearings.

Another question which is of interest is the matter of demand factor of the main roll drive installations at Woodlawn. I would like to ask Mr. Hussey what ratio exists between installed main roll motor rated capacity and the amount of power plant capacity necessary to operate it satisfactorily. To make my question clear, suppose Mr. Hussey planned to install a bar mill having a total of 15,000 HP in individual main driving motors, what would he figure the KW increase in the maximum demand of his power plant would be, as compared to existing conditions.

Another question as to the amount of power required to illuminate the Alliquippa Works. It has been the experience in many mills that the illuminating load has increased quite rapidly in recent years, due to the activity of safety committees in demanding higher illuminating intensities. And the number of KW hours per acre of plant area used for iluminating purposes is the figure in which steel mill electrical engineers are interested.

R. M. Hussey: I agree with Mr. Cummins that electrical storms have been fewer and less severe during the last two years, and this of course, accounts to a large extent for our freedom from lightning troubles. The electrical men at the Alliquippa Works feel, however, that troubles, either from lightning or from surges due to other causes, have been taken care of with fewer circuits involved in outages and with much less damage to equipment than under similar conditions in years past. I do not mean to convey the idea that moving lightning arresters to the outside alone brought about such improvements, improved switching equipment and other improvements in our 6600-volt system helped materially.

Our 6600-volt system is not grounded at the neutral, but whenever we purchased and installed new 6600-volt equipment, it was designed with this idea in mind, grounding the neutral at some future date.

Those old motors to which roller bearings have been applied are all in the mill type class and to date we have experienced shaft breakages in only one size of a particular type of mill motor. We have broken altogether five (5) shafts in this one size motor, but have apparently corrected such a condition by increasing the shaft diameter.

The demand factor about which we have the most complete information refers to one of our recently installed rolling mills and is on the order of 58%, which is the ratio between the hourly rate of using

†Elec. Supt., Carnegie Steel Co., Duquesne, Pa.

power in a 15-minute period, expressed in K.W. to the total connected main drive motor ratings expressed in K.W. In order, however, to provide for a more stable operating condition under peak loads, a factor on the order of 62 to 65% should probably be used.

I have no figures on the K.W. load in illuminating the plant that are based on plant acreage. The total lighting load is about 1800 K.W.

J. S. O'Donovan*: What size motors are equipped with ball and what size with roller bearings? What service do you consider the most severe, geared, belted or direct? What is your most severe application?

R. M. Hussey: The first part of Mr. Donovan's question, in re size of motors using ball and those using roller bearings, is answered in an answer to one of Mr. Moyer's questions below.

We have very little experience to date with a belted-motor equipped with anti-friction bearings. We believe the direct connected job is the least severe. We can conceive of conditions where a geared job would be most severe and still other conditions where a belted job would give the most trouble. We have experienced practically no trouble on our geared drives, the gearing is usually kept in good order.

We believe our most severe application of anti-friction bearings to motors is in the four (4) 100 HP mill type motors on the reversing tables at the Blooming mill.

A. A. Stewart†: 1. Do you use raw or washed Blast Furnace Gas under your boilers, if washed, how many grains of dust per cubic foot remain in the gas?

2. Do you consider the interval of piercing an ingot at your Seamless Plant of too great a duration to be benefited any in smoothing out his Power House Peak Demands by the use of a flywheel?

*Chief Elec., Spang Chalfant & Co., Etna, Pa.
†Elec. Supt., Pittsburgh Steel Co., Monessen, Pa.

R. M. Hussey: 1. Raw gas is used under the boilers. Only that amount of gas used in the stoves goes through a washer.

2. Considering the size of the Mercer motor, 3000 HP the capacity of our power system and the short time in piercing, we did not consider a flywheel set.

F. H. Moyer*: 1. What kind of bearings were used in your motors?

2. On what type of equipment ball bearing motors were used and on what type roller bearing motors were used?

3. On what do you base your decision to use these particular bearings?

R. M. Hussey: 1. Several kinds of bearings are used: S.K.F. self-aligning roller and ball bearings, Rollway roller bearings, a few Hyatt, and one or two sets of various other makes of anti-friction bearings.

2. There has been no distinct dividing line drawn in the use of ball and roller bearings. In purchasing new motors, equipped with anti-friction bearings, we have been guided by both motor and bearing manufacturers. In the larger horsepower, slower speed motors, we have used roller bearings, but in the smaller higher speed motors we have used ball bearings. Roller bearings are used in mill type motors, no ball bearings being used in this type of motor.

3. In answering this question, it is not plain just what Mr. Moyer means by "these particular bearings." If he refers to the anti-friction bearings as a piece of equipment, we decided several years ago to try such a type of bearing in an effort to reduce maintenance costs. The results were so satisfactory that we have continued to apply roller or ball bearings, as the case may be, to old motors, several hundred being so equipped to date. If Mr. Moyer refers to any particular style or make of bearing, we have become partial to the self-aligning type because we expect longer life, fewer failures, and more satisfactory operation by reason of the self-aligning feature.

*Vice President, Mackintosh Hemphill Co., Pittsburgh, Pa.

*Discussion: Electrical Installations New Structural Mills Carnegie Steel Company Munhall, Pa.**

By MEMBERSHIP

W. S. Rugg†: I haven't very much to say; did not expect to have the pleasure of speaking to you. I wanted to have the pleasure of listening to Mr. Menk's description of what we think is a very wonderful accomplishment. I was at this plant a week or so ago and went over the mills with Mr. Menk. I had not been there in about 30 years, and in looking at these Homestead steel mills, I certainly got a thrill out of it. What impressed me more than anything else was not the size of the apparatus, and not the new things that were being done, although there were many, but what you might call the ensemble of the whole job. The ensemble of an enormous undertaking of this kind can only come from men who have vision and know what they want to do. Mr. Menk and those associated with him can well feel proud of what they have done. They have produced a mill which will be considered a real milestone in the production of steel, and I am sure you will get a great thrill in looking at it. The Westinghouse Company are very proud to be associated with this group of men in doing their part in accomplishing a work of this kind.

*Presented at Annual Convention, June 13-18, 1927.
†Vice Pres., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

G. E. Stoltz*: There is no question but what the new work at the Homestead Plant of the Carnegie Steel Company is epoch making in the electrification of the Steel Industry. The work that has been completed is of such a broad scope and has so many new and interesting developments that it is practically out of the question to satisfactorily describe what has been done in the short time we have available. Many of us have attended meetings to listen to the description of some one accomplishment but in this particular case so many engineering problems have been met in a new way that full appreciation of them would only be gained by a visit to the plant where considerable time would be required to investigate everything that is new and of outstanding value.

In the past Mr. Menk and other members of the Iron and Steel Association have had to justify the use of electrical apparatus in the Steel Industry before it would be purchased. Many of us have attended a number of meetings to discuss the merits of steam and electric drive but this we believe can be considered as a past issue and it is now time for the Electrical Engineer in the Steel Industry to determine just what our new problems are. Instead of merely selecting a motor to develop sufficient power to drive a mill, we should be endeavoring to select apparatus that will assist in the process of making steel and in producing a better product at lower cost. Direct current motors of very close speed regulation are now designed to be used on continuous strip mills which not only makes it possible to produce this strip at a lower power cost but enables the operator to roll to thinner gauges and to more accurate gauges.

This afternoon we will see two Universal mills, each provided with three independent screwdowns. One set of rolls will work on the web and the inside of the flanges, another on the outside of the flanges, and the third set on the toe of the flanges. It is necessary to set these three independent screws before each pass in a way that the steel will be reduced uniformly throughout its section. It was decided that it would be impractical to obtain these results if the setting of these three screwdowns was to be left in the hands of the operators. It was for this reason that these screwdowns were made automatic, their setting being determined before a particular schedule of steel is rolled. This not only insures a better product but also accomplishes the work with fewer men.

In the design of the mill equipment we are to visit this afternoon the Carnegie Steel Engineers have endeavored to accomplish three things—

(1) To produce their product with a reduced number of men. For instance the tonnage output per man has been increased six times.

(2) To improve the product rolled and this is particularly noticed in the section obtained in the Universal mill.

(3) To increase the tonnage output. This is not necessarily done by speeding up the mills but by designing the equipment so that the apparatus is inherently designed to meet its particular requirements so that the possibility of failure is reduced to a minimum.

A. N. Diehl*: It is certainly an honor to be asked to be with you today and serve as Chairman at this meeting, and I wish to express my appreciation of the honor.

A number of years ago we went into the question of alteration of our mills at Homestead, and that led to the conclusion that the various Structural Mills should practically be re-designed. Mr. Menk, the author of the paper, has been very closely associated with that work and deserves much credit both from an engineering and installation standpoint. Mr. Menk has been so associated with our electrical problems at Homestead for so many years that we cannot express the value of his efforts too highly.

This afternoon, as Mr. Wales says, you can see the new mills in operation. They are doing wonderful work, and I am sure you will notice a remarkable ease with which they are carrying out their work.

I would like to say that the Carnegie Steel Company extends a real welcome to you at Homestead Steel Works to see for yourselves how Mr. Menk, The Westinghouse Company, and other engineers have accomplished this ensemble, as Mr. Rugg so aptly puts it.

*Industrial Engineer, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

*Vice President, Carnegie Steel Co., Pittsburgh, Pa.

*Discussion: Recent Boiler Plant Installation at Edgar Thomson Works, Carnegie Steel Company**

By MEMBERSHIP

H. C. Siebert‡: I visited the plant yesterday and was very well impressed, with the exception of one or two mechanical details which I thought could have been arranged differently. The main point that impressed me on the proposition was that there is a boiler plant which presents a great contrast with the plants replaced. I believe the erection and operation of the plant eliminated 100 old boilers, mostly of the Cahall vertical type. The average efficiencies of the old boilers was probably 40 per cent, while I dare say the efficiency of the new boilers is approximately 80 per cent. I think it is a great forward step in the demonstration of the fact that in a large modern steel plant, blast furnace gas is one of the economical factors in the manufacture of iron and steel. For the Pittsburgh district we can fix the cost of coke at $4 a ton; we then have the value of blast furnace gas at $2 per ton of iron. Taking the quantity of iron at 600 tons per fce. per day which

*Presented at Annual Convention, June 13-18, 1927.

‡Combustion Engr., Bethlehem Steel Co., Bethlehem, Pa.

is considered a fair production, we have a blast furnace gas value at $1,200. If we realized 40 per cent efficiency and raised it to 80 per cent efficiency, it is quite an important factor and will reduce the cost of iron and steel considerably. I was interested to hear the figures quoted by Mr. Abbiss and I think they can easily be realized. One cannot help but realize that here is a plant that can operate at 75 or 80 per cent efficiency, because it is operated with automatic means of control, which it must have if we wish to realize high efficiency.

Gordon Fox*: The efficient utilization of blast furnace gas is a matter which has acquired tremendous interest. The outstanding progress in such utilization has been in the use for steam power development. The increasing return from the gas through better utilization has given this product of the blast furnace relatively greater importance. The power output, in some instances, is exceeding 150 k.w.h. per ton of iron and an output of 200 k.w.h. per ton is being approached. Today the blast furnace plant which does not use its gas fully and effectively is at no little disadvantage. The trend in this direction is well illustrated by the plant which Mr. Abbiss has ably described.

Walter Flanagan†: One point in the figures just shown not only bears out some past experiences, but also indicates indirectly some of the benefits accruing from air heaters, particularly with blast furnace gas. Mr. Abbiss shows the stack temperature from blast furnace gas fired boilers as 680 to 730°, from coal fired boilers 620 to 800°, and coke breeze fired boilers 700 to 850°. Coke breeze fired boilers thus showing a higher stack temperature than coal fired boilers. I had somewhat the same experience, coke breeze showing about 100°F. higher stack temperature than coal when fired under the same boiler and with the same stoker. The only reason apparent for the difference in temperature is that the coal fired boiler had a higher initial furnace temperature with a greater percentage of heat absorbed by radiation in the first pass. When an air heater is installed to increase the temperature of the combustion air, the heat transmission is increased in the first pass and a lower boiler exit temperature results than would be expected from a heat balance of the air heater.

I would like to hear from Mr. Abbiss about the dust content of blast furnace gas burned and any troubles due to flue dust in the boilers or in keeping tubes clean in the air heaters.

R. D. Abbiss‡: The gas we use at our plant is from Bessemer and Basic furnaces and the dust content is rather variable, especially at the rates we drive our furnaces. As to trouble with the boiler tubes, there is quite a deposit on the tubes and by looking at cross section you will notice a little arch we have in the center of the section, that will gather a deposit unless we blow it off. When we started up the installation we did not know as much about the actions and reactions we were going to get in the combustion chamber, and instead of providing a means of keeping the arch clean, we set about to provide the means to put it afterward, which we have done. The dust is deposited on this middle arch and will build up to a point in ordinately high between the tubes. It also deposits on front bank of tubes and will, if allowed to accumulate to such an extent, interfere with operation of boilers. I think we could justify a preliminary cleaning of gas for boilers with the experiences we are having at the present time.

W. P. Chandler*: The development of the boilers in the steel industry, particularly of large size that are now being used is one of the distinctive features. This house built at Braddock shows particularly large unit being used, in that two boilers are put in the same setting and the successful results indicate that future developments will be even larger than have been shown so far.

B. R. Shover†: The steel industry is to be congratulated on an installation of the character described, which shows that their engineers have the ability and their management the judgment equal to those of the large public Utility companies, who are making every endeavor to reduce the cost of power.

Blast Furnace Gas has so long been considered as good for the production of steam only, that apparently its other possible use has been largely neglected. Many engineers now contend that greater returns can be obtained from coal burned under boilers than by using it in gas producers, and also that blast furnace gas is worth more for metallurgical purposes than for the production of steam. If these contentions are correct, the proper procedure would be to first supply open hearth furnaces and soaking pits with blast furnace gas for fuel and burn whatever may be left under the boilers. At least one plant is now using blast furnace gas in the soaking pits, and in Europe one steel plant is using a mixture of blast furnace and coke oven gas in open hearth furnaces. At this plant the steel has been made continuously for months with an average of only 3,500,000 B.T.U. net per ton of ingots, a figure which has seldom been reached in this country except for a very short time on new furnaces.

Under these conditions the steam produced from theremaining blast furnace gas and from the coke braize, even in a boiler plant such as has just been described, would not be sufficient to supply the necessary power for the entire steel works and it would be necessary to determine whether the additional power requirements could be produced locally from coal for a lower total cost than they could be purchased from a Utility company. The varied conditions in different works would prevent the application of a general solution of the problem, but it does seem that the situation offers an opportunity for ultimate savings and therefore deserves very careful consideration on the part of metallurgists and engineers.

E. W. Trexler‡: The economical use of coke oven and blast furnace gas in heating furnaces, together with waste heat boilers on open hearths, will result in the elimination of coal under boilers, and the only use for coal will be at the coke ovens.

This refers to a steel plant consisting of coke ovens, blast furnaces and electric driven mills.

---

*Elec. Engr., Freyn Engineering Co., Chicago, Ill.

†Special Engineer, Carnegie Steel Co., Carnegie Bldg., Pittsburgh, Pa.

‡Special Engr., Carnegie Steel Co., Braddock, Pa.

*American Heat Economy Bureau, Wabash Bldg., Pittsburgh, Pa.

†Consulting Engineer, Pittsburgh, Pa.

‡Comb. Engr., Bethlehem Steel Co., Johnstown, Pa.

Items of Interest

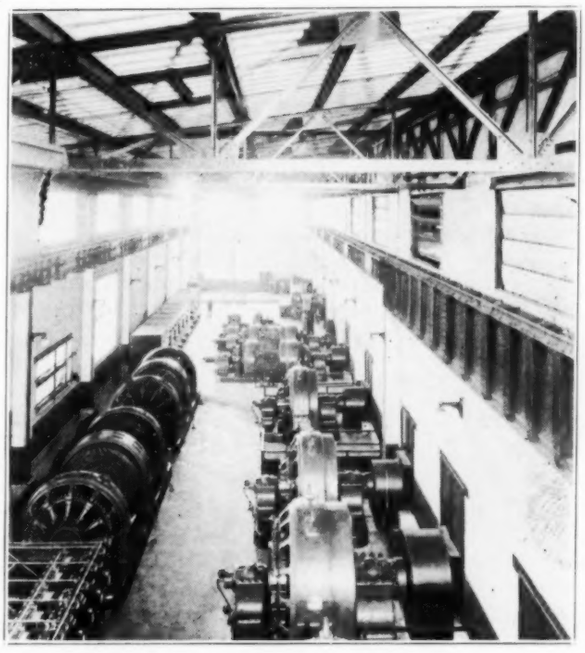
ANNUAL MEETING OF A. I. & S. E. E., ELECTION OF OFFICERS INSPECTION TRIP—JONES & LAUGHLIN STEEL CORPORATION

(Continued from page III)

At 8 p. m. Mr. S. S. Wales, president, announced the election of National Officers for the coming term as follows:

President—A. J. Standing, Elec, Supt., Saucon Plant, Bethlehem Steel Company, Bethlehem, Pa.

First Vice President—C. S. Proudfoot, General Manager, United States Ferro Alloys Corporation, Niagara Falls, N. Y.



14" Mill Motor Room.

Second Vice President—F. W. Cramer, Asst. Elec. Supt., Bethlehem Steel Company, Johnstown, Pa.

Treasurer—James Farrington, Elec. Supt., Wheeling Steel Corporation, Steubenville, Ohio.

Secretary—A. G. Place, Elec. Engr., Youngstown Sheet & Tube Company, Youngstown, Ohio.

Director—W. J. Harper, Combustion Engineer, Donner Steel Company, Buffalo, N. Y.

Director—John Oartel, Chief Safety Engineer, Carnegie Steel Company, Pittsburgh, Pa.

Director—Elbert Lewis, Asst. Elec. Engr., Illinois Steel Company, South Chicago, Ill.

Director—A. L. Reichert, Elec. Supt., Bourne Fuller Company, Cleveland, Ohio.

Director—W. W. Garrett, Bureau of Tests, Electrical Dept., Tennessee Coal, Iron & R. R. Company, Fairfield, Ala.

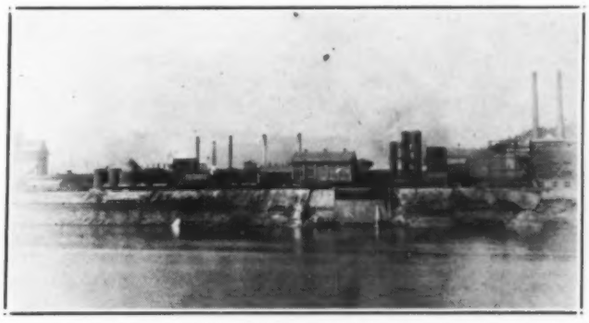
S. S. Wales also announced the election of officers for the Pittsburgh Section as follows:

Chairman—W. E. Miller, Elec. Supt., Bethlehem Steel Company, Johnstown, Pa.

Vice Chairman—R. B. Davenport, Elec. Supt., Carnegie Steel Company, New Castle, Pa.

Committeeman—A. A. Stewart, Elec. Supt., Pittsburgh Steel Company, Monessen, Pa.

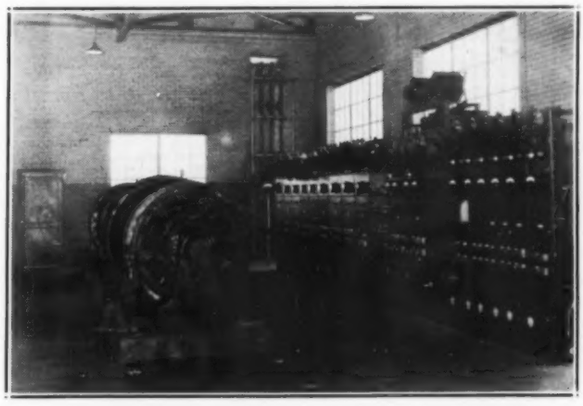
Committeeman—R. M. Hussey, Elec. Supt., Jones & Laughlin Steel Corporation, Woodlawn, Pa.



General View of By-Products Coke Plant.

Committeeman—J. S. Murray, Elec. Supt., Follansbee Brothers Company, Toronto, Ohio.

After the announcement of the election of National and District Officers, Mr. Hussey delivered a paper on "Electrical Installations at the Aliquippa Plant of the Jones & Laughlin Steel Corporation" which was followed by discussion. Both the paper



Interior View of By-Products Substation

and discussion appear in this issue of Iron and Steel Engineer on page 448.

We wish to take this opportunity of again thanking the Jones & Laughlin Steel Corporation for the privilege of inspecting their plant and to congratulate them on the manner in which every detail was handled.

Seventy-five years of water works history are epitomized in the history of the Chicago water works system, as told in a leaflet issued by the De Laval Steam Turbine Co. in connection with the annual meeting at Chicago of the American Water Works

Association. Beginning with a vertical, single acting, condensing steam engine of eight million gallons daily capacity in 1853, the system has grown until it now approximates a daily capacity of one billion gallons per day, of which more than one-half is supplied by fourteen De Laval centrifugal pumps, all except four of which are driven by De Laval geared turbines. The steadily improving economy of this type of pumping unit is indicated by the fact that two 60 million gallons per day units which were tested in 1922 developed on test a duty of 154.36 million foot pounds per thousand pounds of steam, while two similar units tested in 1924 developed 172 million foot pounds per thousand pounds of steam, and two units of the same capacity tested in 1926 gave 191.3 million foot pounds per thousand pounds of steam. All of these units received steam at a pressure of 175 lbs. per square inch, with 150° F. superheat. The four 75 million gallons per day De Laval geared turbine units now being built for the William Hale Thompson Station are guaranteed to develop duties of 203,500,000 feet pounds per thousand pounds of steam. These very high duties, together with the small weight and size of the geared turbine driven pump and the consequent small cost of buildings and foundations, have caused it to sweep aside almost entirely the triple-expansion reciprocating pump, which for so many years held the field unchallenged.

W. J. Jeandron, United States Sales Agent for LeCarbone Carbon Brushes, announces the appointment of A. M. Ramsey as Pittsburgh District Representative with offices located at 634 Wabash building, Pittsburgh.

Mr. Ramsey has represented Mr. Jeandron for the last five years in Chicago, and will be assisted in Pittsburgh by Mr. A. A. Steele.

W. P. Poynton who formerly represented W. J. Jeandron in the Pittsburgh district, has recently severed his connections with this company.

The Wellman-Seaver-Morgan Company, Cleveland, Ohio, announce the incorporation of an Associated Company in Canada, known as the "Canadian Wellman-Seaver-Morgan Company, Limited," under the Dominion Companies Act, with head office at No. 307 Reford Building, Toronto, Canada, and branch office at No. 808 Drummond Building, Montreal, for the handling of the well-known line of this Company's products, which include Coal and Ore Handling Machinery, Mining Machinery, Special Cranes, Port and Terminal Equipment, Steel Works Equipment, Coke Oven Machinery, Gas Producers, and other specialties.

A revolutionary industrial step is reflected in the announcement of the signing of a contract by the Public Service Corporation of New Jersey for the purchase of a minimum of ten billion feet of gas during the next ten years from International Combustion Engineering Corporation's new low temperature coal carbonization plant to be erected at New Brunswick, N. J.

This plant is the first of International Combustion Engineering Corporation's construction of the kind in this country, the process having been in successful commercial operation for several years at Essen, Germany, where thousands of tons of coal have been distilled and the products marketed. This plant will handle approximately 250,000 tons of bituminous slack coal per year through the initial installation of the eight units. In addition to the gas which is a by-product the plant will produce six million gallons per year of coal tar, which has all been contracted for by the F. J. Lewis Mfg. Co. of Chicago; one million two hundred and fifty thousand gallons of crude motor spirits, which is said to be higher in power than the present blended gasoline.

There will also be produced from the coal tar of this plant 2,750,000 gallons per year of the heavier distillates which will find their way into the business of wood preservatives, the manufacture of disinfectants, flotation oils and plastics.

There will be marketed from this plant after the coal is distilled and all of the valuable by-products taken from it approximately 175,000 tons of a domestic smokeless fuel possessing all of the advantages of anthracite with none of its disadvantages such as high ash, of a value of over $1,750,000 a year.

A new leaflet has been released describing the automatic electric melting pots of the Westinghouse Electric and Manufacturing Company. This publication, L-1868-B, covers the applications for which these pots are suitable and gives interesting operating data as well, listing the advantages secured by using this apparatus. The pots described have a maximum operating temperature of 950°F. and are largely used for melting soft metals, such as babbitts, and for low temperature drawing baths in the heat treatment of steel tools and parts.

Copies of this leaflet may be had at any of the district offices or from the Advertising Department at East Pittsburgh, Pa.

The Roller-Smith Company, 233 Broadway, New York, N. Y., announces two new instruments: The Type COM Ohmmeter; the Type HTD Circuit Tester.

These two new instruments are illustrated and described in the copy of Supplement No. 1 to Bulletin No. 300.

The Type COM Ohmmeter was developed to meet the demand for a small, compact, rugged and reliable resistance measuring instrument for measuring resistances from .5 ohm to 50,000 ohms. The fact that it is direct reading, that the self-contained dry cell is easily replaceable and that the design is very novel make the COM Ohmmeter a really new addition to the line of resistance measuring devices heretofore obtainable.

The HTD Circuit Tester is something entirely new and was developed for the purpose of providing a small and reliable device for circuit testing and approximate resistance measurements.

A manually operated indoor oil circuit breaker known as the type E-20 especially designed for the protection of large motors and for general utility in the industrial field has been placed on the market by the Condit Electrical Manufacturing Corporation.

The application of a thermal overload trip device to this oil circuit breaker affording time lag overload protection represents a distinct advance in the design of oil circuit breakers in this capacity.

Housing and frame are of heavy gauge pressed steel. The housing is firmly welded to the frame, supporting the operating mechanism and insulators, on all four sides, totally enclosing all live parts.

The cover is a single piece turned at the edges to exclude dripping, moisture or dust from the breaker interior.

The oil tank is strongly constructed of pressed steel with welded joints and securely supported at four points on the frame. The tank sides fit into a deeply recessed groove on the frame which materially reinforces the tank top.

The tank is provided with a suitable lining and barriers are supplied between poles to give additional protection against arcing under severe conditions.

Both movable and stationary contact members are extra heavy insuring long life and ability to stand up under severe motor service. The movable contacts are strongly supported in a heavy carriage and are provided with helical springs which maintain a high pressure on closing and facilitate the acceleration of the movable member on opening.

The operating mechanism is simple and rugged with a double latch arrangement which makes it vibration proof.

All circuit breakers are equipped with a position indicator which indicates when the circuit breaker is in open or closed position.

The oil circuit breaker is furnished for automatic or non-automatic operation. On automatic operation the circuit breaker will trip free on overload.

Dependable overload tripping is accomplished through the use of a mechanical thermal tripping device used in conjunction with current transformers. It was introduced through the realization that thermal current tripping devices are the nearest approach to ideal motor protection.

Where the heating effect is the limiting factor of operation, the most accurate and satisfactory protection to the motor is given by a thermal device that will permit the motor to run during short overloads, but which will function to stop the motor quickly in the event of a heavy overload or short circuit. The thermal trip of the type E-20 circuit breaker follows closely the motor heating curve and performs this function satisfactorily yet affording protection against short circuit.

The type E-20 oil circuit breaker is furnished for 400 amp. or less, three pole, and has an estimated interrupting capacity of 2400 amps. at 2500 volts.

The Union Metal Products Company of Hammond, Indiana, manufacturers of pressed steel car ends and similar products using steel plate, have solved a problem in material-handling in a manner that should interest other users of steel plates.

Two rectangular lifting magnets, manufactured by The Electric Controller & Manufacturing Company of Cleveland, are hung from a spreader beam which is itself suspended by a cable from a monorail hoist. These plates are charged into a heating furnace one at a time by an operator placed in a control room opposite the end of the furnace. No floor man is used to steady the plates as they are being carried to the charging platform so a mechanical means of assisting the operator was devised.

Two arms were extended out from the monorail hoist parallel to the track and, from the two ends, vertical slides were hung and rigidly braced. On each slide a counterweight was suspended from a cable which runs up over a pulley and down at an angle to the spreader beam supporting the magnets. The counterweights are small but it is remarkable that this rigging is sufficient to hold the magnets perfectly in line and to stop all swinging of a lift after but one or two swings.

A new electric melting pot has been introduced for melting solder, lead, babbitt, tin, etc., which has a capacity of from 27 to 40 pounds, according to the metal to be melted. This pot may be operated on either 110 or 220-volt alternating or direct current circuits and is made in two ratings, 750 and 1,000 watts.

The new pot is a General Electric product and is the smallest size of the G. E., RP form E line. It consists of a durable sheet steel cylindrical casing ten inches deep and nine inches in diameter, in which is supported a cast iron crucible four inches deep and six inches in diameter, inside. The space between the crucible is efficiently insulated with a compact heat insulator.

Heating units are of the cast-in, sheath-wire type so successfully applied to metal melting. One unit is used in each pot, dissipating 750 watts in one rating, and 1,000 watts in the other.

The leads of the unit are brought over the top of the pot into a connection box fixed to the unit itself.

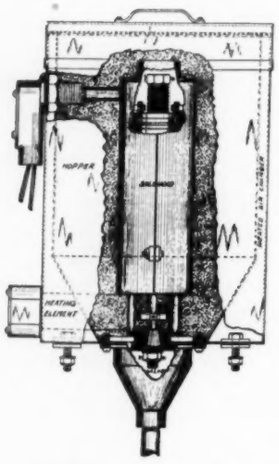
The new pot is designed for melting lead, babbitt, tin, solder and similar alloys or metals, except spelter or zinc, at temperatures not exceeding 950 deg. F. Detailed capacities follow: for 50/50 solder, 30 pounds; for lead, 40 pounds; for babbitt, 37 pounds, and for tin, 27 pounds. The approximate shipping weight is 50 pounds.

"Edmoore" Power Demand Limitator, a patented product is the heading on Bulletin No. 11, published by Edward T. Moore, manufacturer, 500 Cahill Building, Syracuse, New York. The "Limitator" is an electrical device for automatically controlling and limiting the power demands or peak loads on electric power systems for consumers. It is claimed that by its use many small plants are saving large sums every month. The device is generally connected to the main incoming power lines of a consumer's plant so as to summate all power.

The Rollway Bearings Company, Syracuse, N. Y., announce the opening of a Pittsburgh office at 614 Empire Building in charge of Mr. Samuel Farrell.

Mr. Farrell has been very active for the Rollway Bearings Company in working out the application of roller bearings to steel mill problems and he brings to this company a wealth of practical experience gained through his association with the Youngstown Sheet and Tube Company and the Brier Hill Steel Company, which organizations were among the pioneers in the use of roller bearings on mill drives.

It is only a matter of weeks



The Sander with the heated air chamber which keeps the sand in condition for instant response in any weather.

Automatically operated from switch located in the operator's cab.

before Winter will be on the job with snow and ice.

No delays or accidents due to *slippery rails*—if your cranes are equipped with Lintern Electro Magnetic Sanders.

Without sanders there is a constant hazard.

Think of the operator who has to sand the rails by hand—a little slip may prove fatal.

N-L

THE NICHOLS-LINTERN CO.

7960 LORAIN AVENUE CLEVELAND, OHIO

Canadian Rep., Railway & Power Eng. Corp., Toronto, Ont.